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PALEONTOLOGICAL SURVEY, RESOURCE ASSESSMENT, AND MITIGATION PLAN FOR THE SOUTHERN HALF OF THE RIO GRANDE RESOURCE AREA, NORTH-CENTRAL NEW MEXICO

Report to the U.S. Bureau of Land Management,
Albuquerque Office

November 25, 1978

by

Barry S. Kues

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INTRODUCTION

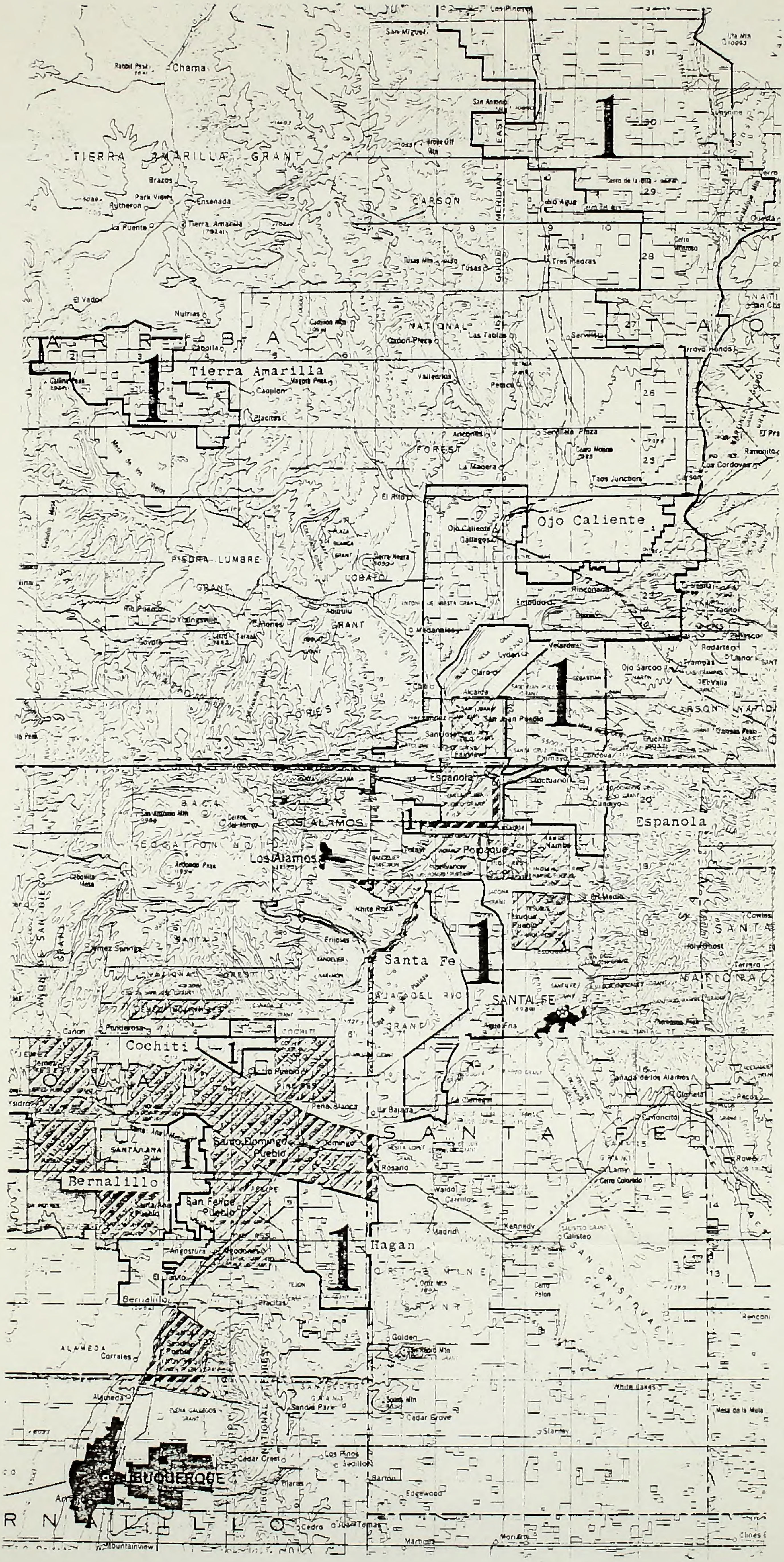
Purpose

The U. S. Bureau of Land Management (B.L.M.) is responsible for managing the resources on federal land within the Rio Grande Resource Area of central and northern New Mexico. This area includes many sedimentary rock exposures that have yielded a variety of important paleontological materials in the past. Because portions of this area are experiencing the effects of increased population growth and energy and mineral development, the B.L.M. required information concerning: 1) the nature, extent, location and significance of paleontological remains that might be affected by these forms of land use, 2) the type and extent of land use activities now existing or imminent, and 3) information regarding appropriate ways to mitigate adverse impacts of land use on the paleontological resources. Such information was needed to aid the B.L.M. in developing land management decisions and programs that would consider paleontological resources within the framework of its multiple use philosophy. The Albuquerque office of the B.L.M. contracted with the University of New Mexico to provide this information for the southern part of the Rio Grande Resource Area (hereafter S.R.G.R.A.), an area of about 450,000 acres (see Fig. 1).

FIGURE 1.

Map of north-central New Mexico showing the areas within the Southern half of the Rio Grande Resource Area. Each area numbered "1", except for the large area in the northeast corner of the map is included in the S.R.G.R.A. Colors indicate land ownership: White - Private land; Yellow - B.L.M. administered land; Blue - State land; Orange - Indian land; Green - National Forest land; Gray - Grants

Names of each of the seven areas, or divisions of the S.R.G.R.A., are informal names of convenience used throughout this report


Chama
Rabbit Peak
Los Pinos
San Miguel
San Antonio
1
31
30
29
28
27
26
25
TIERRA AMARILLA GRANT
Brazos
Park View
Rutheron
Ensenada
La Puente
Tierra Amarilla
CARSON
MERIDIAN
GUIDE
EAST
Ojo Agua
Tres Piedras
Tusas
Tusas Mtn
El Vado
Nutrias
ARRIBA
Cebolla
NATIONAL
Las Tablas
Servilleta
TAOS
Arroyo Hondo
Tierra Amarilla
Canjilon
Vallecitos
Petaca
Placitas
FOREST
Servilleta Plaza
Cerro Mojino
Taos Junction
Carson
Los Cordovas
Ranchitos
La Madera
El Rito
Ojo Caliente
Ojo Caliente
Gallegos
PIEDRA LUMBRE GRANT
Cerro Negro
LOBATO
Abiquiu
GRANT
Rio Puerco
Youngsville
Coyote
Canones
Medanales
Embudo
Rinconada
Velarde
Lyden
Claro
Alcalde
San Juan Pueblo
Hernandez
Santa Cruz
Chimayo
Cordova
Truchas
Ojo Sarco
Las Trampas
El Valle
CARSON NATIONAL
Espanola
Espanola
Cundiyo
Nambe
Pojoaque
Jacona
BACA
San Antonio Mtn
Cerros del Abrigo
LOS ALAMOS
Los Alamos
Cebolleta Mesa
Redondo Peak
White Rock
Frijoles
Tesuque Pueblo
Tesuque
Rio en Medio
SANTA FE
Santa Fe
Santa Fe
Agua Fria
SANTA FE NATIONAL FOREST
CANON DE SAN DIEGO GRANT
Jemez Springs
Canon
Ponderosa
Cochiti
Cochiti Pueblo
Jemez
Ysidro
Pena Blanca
La Bajada
La Cienega
Canada de los Alamos
Glorieta
Pecos
Canoncito
SANTA FE
Santa Ana
Santo Domingo Pueblo
Rosario
Lamy
Cerro Colorado
Bernalillo
Santa Ana Pueblo
San Felipe Pueblo
Waldo
Cerrillos
Kennedy
Galisteo
SAN CRISTOBAL GRANT
Hagan
Angostura
Algodones
El Tanto
Bernalillo
Placitas
Golden
Ortiz Mtn
Cerro Pelon
ALAMEDA
Corrales
Sandia Pueblo
Alameda
Sandia Park
Cedar Grove
Stanley
White Lakes
Mesa de la Mula
Cedar Crest
Los Pinos
Sedillo
Barton
Edgewood
ALBUQUERQUE
Cedro
Juan Tomas
Moriarty
Mountainview
Clines
BERNALILLO
CIBOLA NATIONAL FOREST

Methods

A thorough survey of existing information on the paleontology of rocks exposued within the S.R.G.R.A. was made. This study comprises several facets: 1) a comprehensive literature search, including published and published sources, and documented by an annotated bibliography of paleontological references, 2) examination of significant collections and records of past paleontological work at institutions that have done paleontological work in the study area, 3) contacts with scientists having first-hand knowledge of the paleontological resources and collecting activities within the S.R.G.R.A., including close consultation with Mr. Ted Galusha, who directed the American Museum of Natural History's (A.M.N.H.) extensive collecting activities in north-central New Mexico for 23 years, and 4) field studies designed to check areas previously reported as being fossiliferous as well as exposures for which no paleontological information was available, and to assess the present and potential impact of land use activities on fossiliferous strata throughout the S.R.G.R.A.

Unlike most areas in New Mexico, many parts of the S.R.G.R.A. have received intensive and continuous attention by paleontologists, and the nature, distribution and abundance of the fossils in some of the stratigraphic units is well known. As a result, much of our time was allocated towards documenting in as much detail as possible the results of previous paleontological activity. Fieldwork was limited to sampling various areas where substantial amounts of fossils had been collected in the past, prospecting some areas for which there was little or no previous information, and observing and documenting land use activity.

A team of undergraduate and graduate paleontology students from U.N.M. was assembled by the Principal Investigators to participate in this survey; they were utilized primarily in the field. Students participating included undergraduates Tom Lehman, Mike O'Neill, Pete Reser, and Martha Summerville; and graduates Pete Hutchinson, Tim Gorham, Scott Griffiths, and Mike Vazzana. The last three students are doing Master's theses that include parts of the S.R.G.R.A., and they interfaced some of their field studies with this survey. Fieldwork was directed by Spencer Lucas, a vertebrate paleontologist completing a Doctoral degree at Yale University. Lucas was also responsible for the identification of vertebrate fossils found during the field work.

GEOGRAPHIC SETTING

The S.R.G.R.A. includes seven isolated areas along both sides of the Rio Grande River, extending roughly from Albuquerque north to Ojo Caliente, with one division along the Nutrias River immediately south of the Tierra Amarilla Grant . For ease of reference, we have given each of the seven divisions an informal name; these names are indicated on Figure 1 and will be used in the remainder of this report. Part of the S.R.G.R.A. is situated in one of the most heavily populated areas of New Mexico; the implications of this fact will be discussed at length later.

PREVIOUS WORK - STRATIGRAPHY AND PALEONTOLOGY

Introduction

Within the S.R.G.R.A. are sedimentary formations of Jurassic, Cretaceous, Tertiary and Quaternary age, a substantial number of Tertiary volcanic flows, and a small amount of Precambrian rocks that are mostly granite (Fig. 2). Because paleontological remains are almost non-existant in volcanics and Precambrian granites, we devoted our attention completely to the sedimentary units except for noting the location and type of non-sedimentary rocks during our reconnaissance field work.

Exposed sedimentary units are limited primarily to the Cretaceous Mancos and Mesa Verde formations, Eocene Galisteo Formation, and the Mio-Pliocene Santa Fe Group (Table 1). The types of sedimentary and other rocks within the S.R.G.R.A. varied considerably from place to place; a summary of the distribution of different rock types is presented in Table 2. Sedimentary rocks are exposed over about 72%, alluvium over 6%, and volcanic and Precambrian rocks over 22% of the total S.R.G.R.A.

Stratigraphy and Paleontology

Broad aspects of the stratigraphy and previous paleontological work in the sedimentary units of the S.R.G.R.A. are considered here. This summary is a synthesis of previous work but also incorporates some of our observations while in the field. For additional information on paleontology relative to land use, see a later section of this report.

Morrison Fm. - A small area of Morrison is exposed in the Tierra

FIGURE 2. Geologic map of the S.R.G.R.A.

Key: Red cross-hatch = Morrison (Jurassic)
Olive green = Dakota (Late Cretaceous)
Green = Mancos & Mesa Verde (Late Cretaceous)
White = Galisteo (Eocene)
Orange = Santa Fe Group (Miocene-Pliocene)
Yellow = Quaternary pediments and alluvium
Pink = Tertiary & Quaternary volcanics and volcaniclastics
Blue = Precambrian

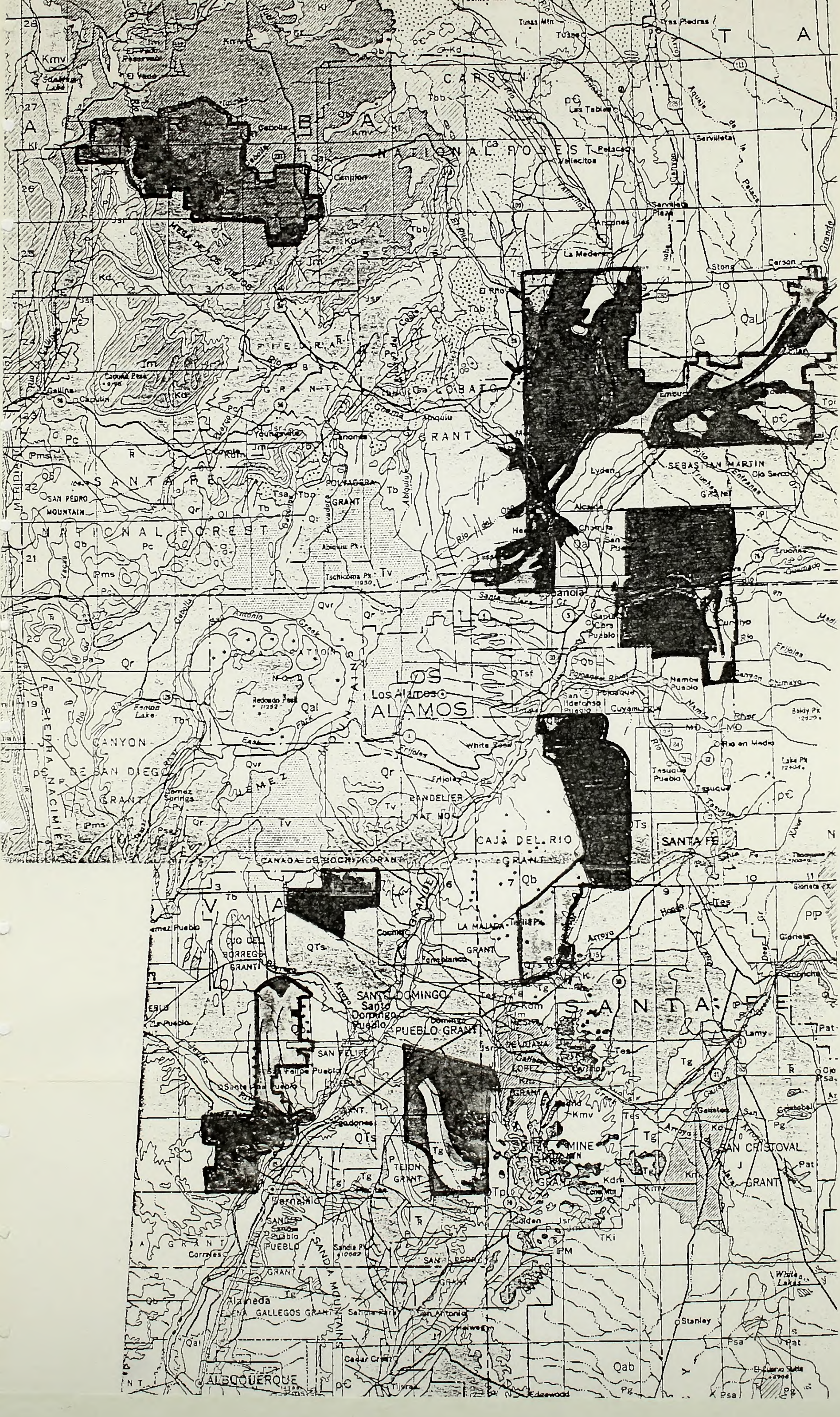

CARSON NATIONAL FOREST
Tusas Mtn
Tres Piedras
El Vado Reservoir
El Vado
Cebolla
Canjilon
Las Tablas
Vallecitos
Petaca
Servilleta
Servilleta Plaza
Ancones
La Madera
Ojo Caliente
El Rito
Stong
Carson
MESA DE LOS VIEJOS
PIEDRA LUMBRE GRANT
Gallina
Capulin
Youngsville
Coyote
Canones
Abiquiu
POLVADERA GRANT
Abiquiu Pk
Tschicoma Pk 11950
SAN PEDRO MOUNTAIN
SANTA FE NATIONAL FOREST
Rio Chama
Embudo
SEBASTIAN MARTIN GRANT
Lyden
Alcalde
Chamita
San Juan Pueblo
Espanola
Santa Clara Pueblo
Santa Cruz
Truchas
Chimayo
Nambe Pueblo
San Ildefonso Pueblo
Pojoaque
Cuyamungue
VALLES CALDERA
Redondo Peak 11252
LOS ALAMOS
Los Alamos
JEMEZ MOUNTAINS
Fenton Lake
CANYON DE SAN DIEGO GRANT
SIERRA NACIMIENTO
Jemez Springs
White Rock
BANDELIER NAT MON
Tesuque Pueblo
Tesuque
Rio en Medio
Baldy Pk 12622
Lake Pk 12409
CAJA DEL RIO GRANT
SANTA FE
CANADA DE COCHITI GRANT
LA MAJADA GRANT
Cochiti
Pena Blanca
Jemez Pueblo
OJO DEL BORREGO GRANT
SANTO DOMINGO PUEBLO GRANT
Santo Domingo Pueblo
SAN FELIPE
San Felipe Pueblo
Santa Ana Pueblo
Algodones
TEJON GRANT
Bernalillo
Placitas
SANDIA PUEBLO
Sandia Pk 10682
SANDIA MOUNTAINS
Corrales
Alameda
ELENA GALLEGOS GRANT
Sandia Park
San Antonio
Cedar Crest
Tijeras
Edgewood
ALBUQUERQUE
SAN PEDRO GRANT
Golden
ORTIZ MINE GRANT
Cerrillos
Galisteo
Lamy
Glorieta
Canoncito
SAN CRISTOVAL GRANT
Stanley
White Lakes
Kmv
Kd
Jm
Jsr
Kdm
Tbb
Tb
Tv
Qal
Qb
Qr
Qvr
QTs
QTsf
Pc
Pms
Pa
Tg
Tes
Tp
Psa
Pg
Pat
Ts
pC

TABLE 1. Sedimentary and layered volcaniclastic rocks exposed in the S.R.G.R.A. * = unfossiliferous in S.R.G.R.A.

UNIT			AGE	AREA
Espanola Fm			Pleistocene	Espanola,Ojo Calient
*Servilleta Fm			Pleistocene	Ojo Caliente
*Ancha Fm			Pleistocene	Santa Fe
*Puye Cgl			Pleistocene?	Ojo Caliente
SANTA FE GROUP	Chamita Fm		Pliocene	Ojo Caliente
	Tesuque Fm	Ojo Caliente	Pliocene	Ojo Caliente, Hagan, Espanola, Cochiti, Santa Fe, Bernalillo
		Chama-el Rito	Mio-Pliocene	
		Pojoaque	Pliocene	
		Skull Ridge	Miocene	
		Nambe	Miocene	
*Espinaso Volc.			Miocene	Hagan, Ojo Caliente
*Picuris Tuff			Miocene	Espanola
Abiquiu Fm			Miocene	Ojo Caliente
Galisteo Fm			Eocene	Hagan
*El Rito			Eocene?	Espanola, Ojo Caliente
Mesa Verde Fm			Late Cretaceous	Hagan
Mancos Sh			Late Cretaceous	Tierra Amarilla, Hagan
Dakota Ss			Late Cretaceous	Tierra Amarilla
*Morrison Fm			Late Jurassic	Tierra Amarilla

TABLE 2. Distribution of exposed rock types in the S.R.G.R.A. Figures refer to number of 1/8 townships underlain by the type of rock indicated. Abbreviations: PreC = Precambrian; J_M = Morrison Fm K_D = Dakota Ss; K_M = Mancos Sh.; K_{MV} = Mesa Verde Group; E_G = Galisteo Fm.; T_{SF} = Santa Fe Group; T_V = Tertiary volcaniclastics QT_V = Tertiary and Quaternary volcanics; Q = Quaternary alluvium

S.R.G.R.A. region	PreC	J_M	K_D	K_M	K_{MV}	E_G	T_{SF}	T_V	QT_V	Q		
Tierra Amarilla	-	*	8	16	-	-	-	-	-	-		
Ojo Caliente	8	-	-	-	-	-	33	3	5	4		
Espanola	2	-	-	-	-	-	19	-	-	-		
Santa Fe	-	-	-	-	-	-	12	-	6	-		
Hagan	-	-	-	-	3	2	5	1	-	2		
Cochiti	-	-	-	-	-	-	4	-	1	-		
Bernalillo	-	-	-	-	-	-	3	-	5	2		
TOTAL	10	*	8	16	3	2	76	4	17	8	=	144
% OF TOTAL AREA	7	-	6	11	2	1	52	3	12	6	=	100%

Amarilla division along the Rio Chama. Exposures here are very poor and are largely covered by eroded blocks of Dakota Sandstone that weather from the upper parts of the canyon. No fossils have been reported from the Morrison in the S.R.G.R.A., and the exposures are so inconsequential compared to other outcrops in central New Mexico that the presence of vertebrate fossils is extremely unlikely.

Dakota Sandstone (Late Cretaceous)

The Dakota Sandstone is exposed only in the western half of the Tierra Amarilla division and is primarily limited to cliffs of well indurated sandstone along rivers and streams, in places capping the edges of canyons. The formation represents a transgressive shoreline or lagoonal sand deposit that has yielded few fossils, and none have been reported or found by us within the S.R.G.R.A. Dakota exposures elsewhere in New Mexico have a poorly diverse fauna consisting of mostly cephalopods and bivalves. Near, but not within the Tierra Amarilla division, plant impressions, "borings", carbonaceous material and unidentifiable bivalve casts have been reported (Doney, 1968).

Mancos Shale (Late Cretaceous)

Mancos Shale is exposed over much of the Tierra Amarilla division. In most cases the exposures are poor, intermittent, and consist primarily of the lower Mancos units, specifically the Graneros and Greenhorn Members, but also include Carlile and Niobrara equivalents. The Graneros is very widespread and distinctive, being composed predominantly of "dark gray to black, thin-bedded, fissile sandy shale." (Bingler, 1968). These shales erode easily into valleys and good exposures are only present at the base of ridges held up by the more resistent Greenhorn Limestone, or along stream and road cuts. The Greenhorn is a thin-bedded, platy gray to gray-green shaly limestone frequently present near or at the top of ridges and hills. Shale layers overlying the Greenhorn tend to be gray to dark gray or tan, readily eroded, and crop out most conspicuously along the Rio Nutrias, the northern boundary of the Tierra Amarilla division. Because the shales erode easily they are typically highly vegetated and good outcrops are covered by soil derived from the shale. Additionally, many of the low ridges and hills of Mancos within the Tierra Amarilla area are covered by pediment gravels that obscure what bedrock is exposed. Marine fossils are ubiquitous in these Mancos units, but can only be collected from relatively fresh exposures. Fossils are more abundant in the shales than in the Greenhorn Limestone.

A small area of Mancos exposures is also present in the extreme south and west parts of the Hagan division. These exposures are largely covered by alluvium.

Few specific fossil localities have been reported from Mancos exposures in either the Tierra Amarilla or Hagan divisions, but marine fossils are present in most outcrops. These fossils have not been studied in any detail (except for Cobban, 1969)and they appear in the literature in faunal lists.

For the Tierra Amarilla area the following locality and faunas have been reported:

Locality: SW$\frac{1}{4}$ sec. 29, T 27 N, R 2 E (Dane, 1960)

Fauna: (Doney, 1968; Muehlberger, 1967)

Graneros Shale

- *Exogyra columella*
- *Gryphaea newberryi*

Greenhorn Limestone

- *Inoceramus labiatus*

Carlile Shale

- *Gryphaea* cf. *G. newberrryi*
- *Inoceramus dimidius*
- *I.* sp.
- *Ostrea lugubris*
- *Crassatellites* sp.
- *Collignoniceras woolgeri*
- *Scaphites warreni*
- *Sciponoceras gracile*
- *Prionocyclus wyomingensis*
- *Baculites* sp.
- "fish scales"
- *Ptychodus* sp.

"Upper shales"

- *Ostrea congesta*
- *Inoceramus barabini*
- *I. grandis*
- *I. sagensis*
- *I.* sp.
- *Cardium* sp.
- *Unio* sp.
- *Tellina* sp.
- *Cyprimeria* sp.
- *Lunatia* sp.
- *Cymbophora* sp.
- *Goniobasis* sp.
- *Margarites* sp.
- *Pyrgulifera* sp.
- *Turbonilla* sp.
- *Baculites ovatus haresi*
- *B.* sp.
- foraminifera

For the Hagan area, no specific localities have been reported, but Kelley & Northrop, 1975; Cobban, 1969; Stearns, 1953; and Herrick & Johnson, 1900 have reported the following fossils:

Fauna:

BIVALVIA

- *Anatina* sp.
- *Anomia* sp.
- *Cardium* sp.
- *Crassatella andrewsi*
- *Inoceramus* "*fragilis*"
- *I.* sps (very large)
- *Isocardia* sp.
- *Lopha lugubris*
- "*Mactra*"? spp.
- *Mytiloides labiatus*
- *M.*? aff. *stantoni*
- "*Ostrea*" sp.
- "*Pecten*" sp.
- *Pholadomya* sp.
- *Pinna petrina*
- *Platyceramus*? aff *sagensis*
- *Plicatula* sp.

GASTROPODA

- *Acteon* sp.
- *Carota dalli*
- *Gyrodes* sp.
- *Pyropsis*? sp.
- *Turritella* aff *T. whitei*
- *Volutomorpha novamexicana*

CEPHALOPODA

- *Collignoniceras*, 2+ sp.
- "*Pachydiscus*" sp.
- *Placenticeras* spp.
- *Prionocyclus wyomingensis*
- *Scaphites warreni*

TRACE FOSSILS

- *Ophiomorpha major*
- worm tracks and burrows

Juana Lopez Member (Mancos Shale)

The type section for this member is a few miles northwest of the Hagan division of the S.R.G.R.A., and exposures of this member were identified by us in several places in the Hagan and Tierra Amarilla divisions. Nothing has been reported of the fossils in the Juana Lopez within these divisions, but they are no doubt similar to those in the type location, listed below, from Dane, Cobban and Kauffman (1966)

BIVALVIA

Inoceramus dimidius

I. perplexus

Lopha lugubris

Lucina cf. *L. mattiformis*

CEPHALOPODA

Coilopoceras colletti

Prionocyclus macombi

P. wyomingensis wyomingensis

P. w. elegans

Scaphites ferroensis

S. warreni

S. whitfieldi

Baculites cf. *B. besairei*

Mesa Verde Formation (or Group, in other parts of New Mexico) (Late Cretaceous)

The Mesa Verde Formation is present in a narrow band near and north of the abandoned town of Hagan. It consists of light gray to tan, thick, massive, ridge and cliff forming marine sandstones and intercalated brown to dark gray shale layers, some of them containing coal beds. Mining of this coal occurred for a few years around Hagan but no mining is done now (see land use section for additional information). The marine sandstones contain mainly mollusc fossils in relative abundance in the exposures around Hagan, including a couple of type specimens. The following localities and fossils have been reported by Kelley and Northrop (1975), Cobban (1969), Stearns (1953), Reeside (1927), Knowlton (1917), Lee (1910), and Herrick and Johnson (1900). Some plant fossils are present in and near the coal beds. Little detailed study of any of these fossils has been done.

Localities:

1. Hagan coal field, T 13 N, R 6 E, Sandoval Co., near base of Mesa Verde Group (Reeside, 1927)
2. Hagan coal mine, T 13 N, R 6 E, Sandoval Co. (Reeside, 1927)
3. SW¼ sec. 34, T 13 N, R 6 E (Stearns, 1953)
4. SE¼ sec. 33, T 13 N, R. 6 E (Stearns, 1953)
5. NE¼ sec. 36, T 14 N, R 5 E (not in study area but adjacent to it, Stearns, 1953)

Fauna and Flora

BIVALVIA

Anomia sp.

Cardium sp.

Crassatella shumardi

Crassatellites andrewsi

Cymella montanensis

Cyprimeria sp.

Endocosta? barabini

Ethmocardium pauperculum

E. winchelli?

Idonearca? sp.

"*Inoceramus*" sp.

Legumen aff. *L. planulatum*

Lithophaga sp.

Lopha aff. *L. lugubris*

L. sp.

"*Mactra*" aff. "*M.*" *formosa*

"*M.*" aff. "*M.*" *grandis*

◆ "*M.*" *pulchella*

"*M.*" spp.

"*M.*"? spp.

Modiolus sp.

Mytiloides? aff. *M. stantoni*

Nuculana sp.

"*Ostrea*" *anomioides*

"*O.*" *elegantula*

"*O*," sp.

Pinna sp.

Syncyclonema n. sp.

"*Tellina*" sp.

Trigonarca cf. *T. obliqua*

GASTROPODA

Acteon sp.

Anchura? sp.

◆ *Buccinopsis? occidentalis*

Fasciolaria? sp.

Gyrodes cf. *G. conradi*

G. sp.

Lunatia sp.

Odontofusus? sp.

Pterocerella sp.

Pyrifusus? sp.

Pyropsis? sp.

Turris sp.

Turritella sp.

Volutoderma? sp.

◆ *Volutomorpha novamexicana*

CEPHALOPODA

Baculites aquilaensis

B. ovatus var. *haresi*

B. sp indet.

Eutrephoceras alcesense

E. dekayi

Placenticeras intercalare

P. meeki

P. planum

P. whitfieldi (probably = *P. meeki*)

P. spp.

P. (*Stantonoceras*) aff. *guadalupe*

* *P.* (*S.*) *sancarlosense*

Scaphites aff. *S. hippocrepis*

* *S. leei* III (= *S. leei* var. *parvus*)

TRACE FOSSILS

Ophiomorpha major

FISHES

Lamna sp.

fish vertebrae

PLANTS (note: Kelley & Northrop (1975) reported that Hickey had stated in a letter that most names assigned to Late Cretaceous plants from this area were incorrect. No modern taxonomic review has been done.

"alga"

Brachyphyllum macrocarpum

B. sp.

Carpites sp.

Cyperacites sp.

Dalbergia sp.

Ficus eucalyptifola

F. leei

F. cf. *F. multinervis*

F. praetrinervis

F. speciosissima

F.? *starkvillensis*

F. wardii

F. spp.

Gleichenia rhombifolia

Juglans similis

Myrica torreyi

Nelumbo intermedia

Protophyllocladus sp.

Quercus sp.

Trapa? *microphylla*

Viburnum sp.

"petrified wood"

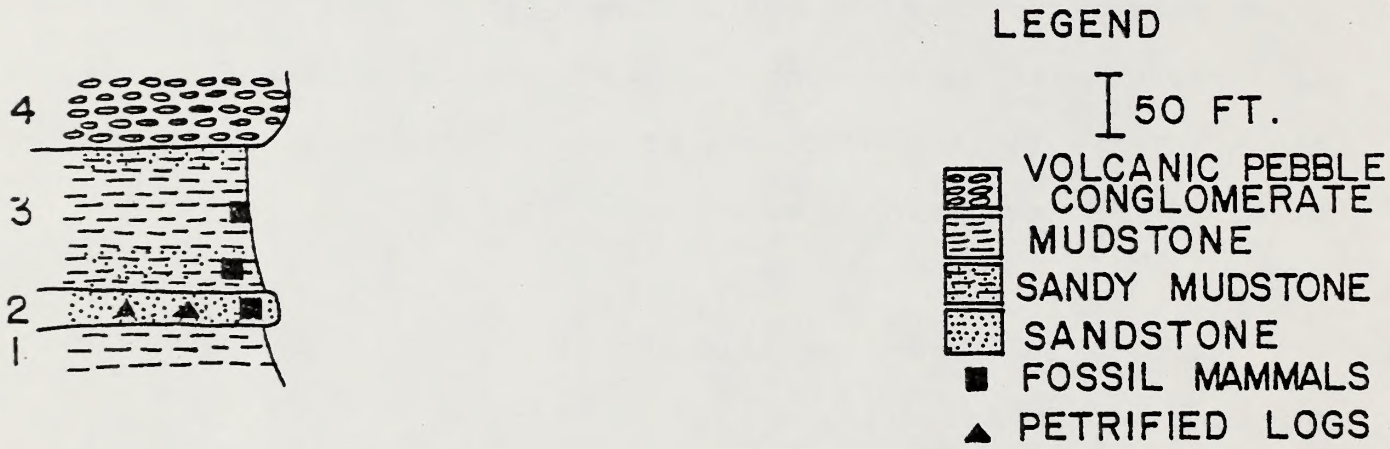
Introduction. Three significant areas of Galisteo exposures are present along the Rio Grande between Albuquerque and Santa Fe; only one (Arroyo del Tuerto area) is within the S.R.G.R.A. and has been prospected thoroughly. The two Galisteo areas outside of the S.R.G.R.A. - east of Cerillos, and south of San Ysidro - have been surveyed incompletely by past workers.

The Galisteo Formation is a thick sequence of variegated sandstone, clay shale, mudstone, and lesser amounts of conglomerate, fresh water limestone and tuff. These lithologies were all deposited in a terrestrial environment by meandering and braided streams. In the study are limited exposures of the Galisteo are present in tributaries of Tonque Arroyo, near Hagan (Fig. 3).

Localities. Only specific localities within the Arroyo del Tuerto area are listed.

1. SW$\frac{1}{4}$ NE$\frac{1}{4}$ SW$\frac{1}{4}$ sec. 4, T 13 N, R 6 E, near the head of Arroyo del Tuerto (= Arroyo Pinovetito). Stearns' Quarry, a thin layer of many vertebrate bones. (UNM-V-013)
2. Same co-ordinates as above, but about 150 ft downstream from Locality 1 on the South bank of the Arroyo del Tuerto; partial titanothere mandible with teeth. (UNM-V-014)
3. SE$\frac{1}{4}$ SW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 4, on North side of Arroyo del Tuerto, about 1000 ft North of Locality 1; partially articulated vertebrate limb elements. (UNM-V-015).
4. SW$\frac{1}{4}$ NW$\frac{1}{4}$ NW$\frac{1}{4}$ sec. 4, about 1000 ft North of Locality 3; titanothere tooth rows. (UNM-V-016).

FIGURE 3. Measured section of the uppermost Galisteo Formation and lowermost Espinaso volcanics in section 4, T 13 N, R 6 E, showing fossil vertebrate localities collected by the University of New Mexico prior to this survey. Units 1, 2, and 3 are part of the Galisteo; unit 4 is Espinaso. Stearns bone bed occurs in the upper half of unit 3 (from an unpublished paper by W. Gavin, 1977).



These localities are within the uppermost Galisteo along or near the Arroyo del Tuerto. Locality 1 is a thin bone bed that was first described by Stearns (1943, p.310-311), and has been collected by the University of California at Berkeley, University of Colorado, and most recently by the University of New Mexico. These collections consist entirely of titanothere remains. Although two size grades are present, they may all pertain to one species (but see letter from Robinson,Appen. 1). Based primarily on size considerations, the material seems referable to Protitanotherium, a Late Eocene (Duchesnean) form. Much fossil material remains in this area, and a large scale quarrying of the bone bed is badly needed. The only other fossils present within this area are abundant fragmented petrified logs.

Summary of Galisteo Fossils. Fossils thus far identified from the Galisteo Formation in central New Mexico are summarized below. Taxa from within the S.R.G.R.A. are asterisked. This information comes from Stearns (1943), Kelley & Northrop (1975), and observations on collections at the Universities of California at Berkeley, Colorado, and New Mexico, and the American Museum of Natural History. Fossils from the S.R.G.R.A. are indicated by an asterisk.

Fauna and Flora:

PLANTS
*?_Quercus_ sp.
*?_Fagus_ sp.
*?_Acacia_ sp.
* _Pitoxylon_ sp.
* poplar?
Sabal? ungeri
Dryopteris? sp.
*"Petrified logs"

VERTEBRATES
Osteichthyes
Lepisosteus sp.
Reptilia
Trionychidae
Family indet.
Mammalia
Carnivora
Uintacyon sp.
Condylarthra
Oxyclaenidae
Hyopsodus sp.
Pantodonta
Coryphodon sp.
Perissodactyla
Brontotheroidea
*?_Protitanotherium_ sp.
*_Teleodus_ sp.
Gen. et sp. indeterminate
Tapiroidea
Homogalax sp.
Rhinoceratoidea
unident. hyracodontid

Of the Galisteo areas not surveyed, the small outcrop south of San Ysidro (Galusha, 1966; some have erroneously referred it to the San Jose Formation) has yielded a titanothere skull and other material now at the American Museum of Natural History, from a total of four different sites. The outcrops northeast of Cerillos have produced sparse Wasatchian (early Eocene) fossils apparently from the lower part of the unit. Petrified wood, especially logs weathering out of channel sandstones, are common. Much of this wood is of commercial quality and the largest concentration occurs on the "Sweet's Ranch" locality east of Cerillos. Vertebrate fossils are rare, but include

Coryphodon (Robinson, 1957), which indicates a Wasatchian age for these exposures. Recent University of New Mexico prospecting has turned up additional material, but in general, the Galisteo has few vertebrate fossils. Of additional interest is the fact that the petrified wood in this area was apparently the first fossils of New Mexico to be reported (Kelley & Northrop, 1975, p. 66).

The only Galisteo beds within the S.R.G.R.A. ofsubstantial paleontological importance are those in the Arroyo del Tuerto and vicinity.

SANTA FE GROUP

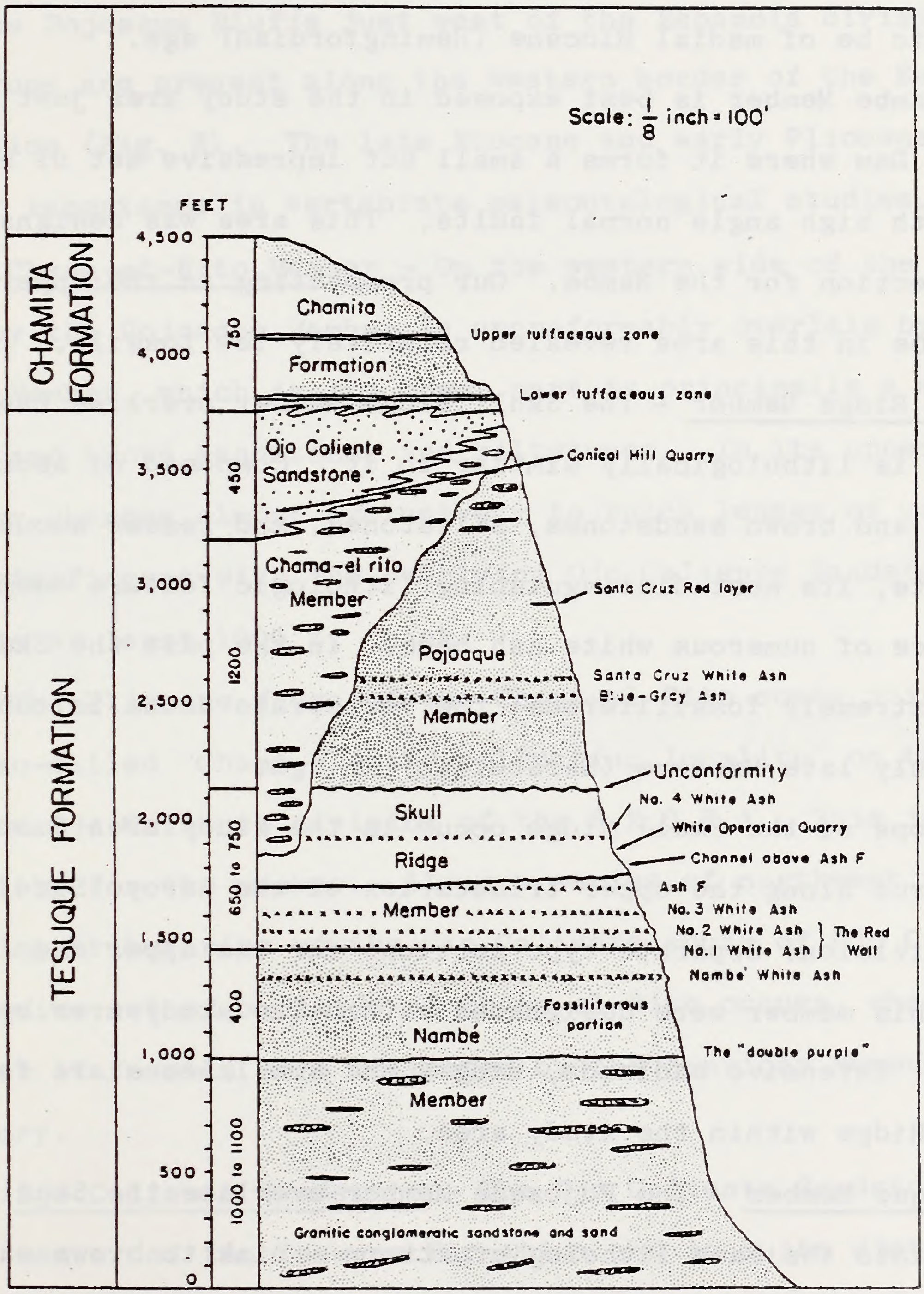
Introduction and General Geology

The Santa Fe Formation (now Group) was the first formation named in New Mexico and consequently has had a long and complex nomenclatural history. It has also had the longest history of continuous collection of fossil vertebrates of any Tertiary fauna in the world, which is why our discussion of this unit will be much longer and more detailed than that of any other unit. Throughout our work we have followed the rock stratigraphic definitions of Galusha and Blick (1971). These definitions are primarily designed for use in the "Espanola Basin-Abiquiu Re-entrant" area, a major portion of the S.R.G.R.A. They are also intimately related to the occurrence of vertebrate fossils and thus provide a convenient biostratigraphic framework within which to work. Unfortunately, some of the units defined by Galusha and Blick are difficult to distinguish in the field and consequently fall short of the ideal concept of the mappability of rock stratigraphic units. We thus realize that revision of some of these units is needed (and in progress); our use of Galusha and Blick's stratigraphic framework is partly a matter of convenience rather than a positive acceptance of all parts of it.

The Santa Fe Group of Galusha and Blick is a Miocene-Pliocene sequence of terrestrial sandstones, siltstones, shales and conglomerates comprising the Tesuque and Chamita Formations (Fig. 4). The Tesuque Formation is a very thick (about 4000 ft) formation subdivided by Galusha and Blick into five members:

Nambe Member - The lowermost member of the Tesuque is about 1500 ft thick and can be subdivided into two halves. The lower half is a

FIGURE 4. Stratigraphy of the Santa Fe Group (from Galusha and Blick, 1971).



predominantly an arkosic conglomeratic sandstone which Galusha and Blick found to be unfossiliferous. The upper half, a series of pink and brown sandstone and siltstone with minor amounts of conglomerate contains several prominent ash layers. This half of the Nambe has produced an abundant and varied vertebrate fauna considered by Galusha and Blick to be of medial Miocene (Hemingfordian) age.

The Nambe Member is best exposed in the study area just west of Santa Cruz Dam where it forms a small but impressive set of badlands riddled with high angle normal faults. This area was designated as the type section for the Nambe. Our prospecting in the upper part of the Nambe in this area revealed relatively few fossils.

Skull Ridge Member - The Skull Ridge Member overlies the Nambe Member and is lithologically similar to it. Composed of about 700 ft of pink and brown sandstones, siltstones, and lesser amounts of conglomerate, its most distinguishing lithologic feature seems to be the presence of numerous white ash beds. In the past the Skull Ridge and been extremely fossiliferous; the vertebrate fauna is considered to be roughly late Miocene (Barstovian) in age.

Outcrops of the Skull Ridge occur in the study area just southeast of Santa Cruz along the upper tributaries of the Arroyo Seco, in the Espanola division. Separate type sections for the upper and lower parts of this member were designated within the study area by Galusha and Blick. Extensive badlands, ridges and small mesas are formed from the Skull Ridge within the study area.

Pojoaque Member - The Pojoaque Member overlies the Skull Ridge and falls into the same lithologic pattern - pink to brown sandstones and siltstones and occasional conglomerates. It is over 1200 ft thick.

Although some ash beds are present, the numerous ash beds seen in the Skull Ridge Member are gone. Like the Skull Ridge, however, the Pojoaque has been and continues to be highly fossiliferous. Most of the type specimens of fossil vertebrate genera and species from the Santa Fe Group come from the Pojoaque Member. Its type locality is in the Pojoaque Bluffs just west of the Espanola division, and some outcrops are present along the western border of the Espanola division (Fig. 5). The late Miocene and early Pliocene fauna is of great importance in vertebrate paleontological studies.

Chama-el-Rito Member - On the western side of the Rio Grande Valley the Pojoaque Member is unconformably overlain by the Chama-el-Rito Member, which in its lower part is principally a series of pink, gray and brown sandstones and siltstones. In its upper part this member changes almost exclusively to thick lenses of volcanic pebbles. It interfingers with the overlying Ojo Caliente Sandstone (Fig. 6) and is at least 1000 ft thick.

The Pliocene fauna of the Chama-el-Rito comes principally from the so-called "Chama-el-Rito collecting locality" on the western edge of the Ojo Caliente division of the S.R.G.R.A. This is also the type locality for the member. Along a series of northwest to southeast flowing tributaries of the Rio Caliente south of Ojo Caliente a very extensive set of badlands of Chama-el-Rito occurs, where a fair number of fossils were collected by the American Museum of Natural History.

Ojo Caliente Sandstone - The Ojo Caliente Sandstone is the uppermost member of the Tesuque Formation and is quite distinct from the other members. It is a pink to buff, little consolidated, well sorted quartzose sandstone, about 400 ft thick, with large scale cross

FIGURE 5. Measured section of part of the Pojoaque Member, Tesuque Formation, in sec. 29, T 21 N, R 9 E. Unit 2 is a green silty bone producing horizon. Units 1-5 are the Pojoaque Member; unit 6 is a pediment gravel.

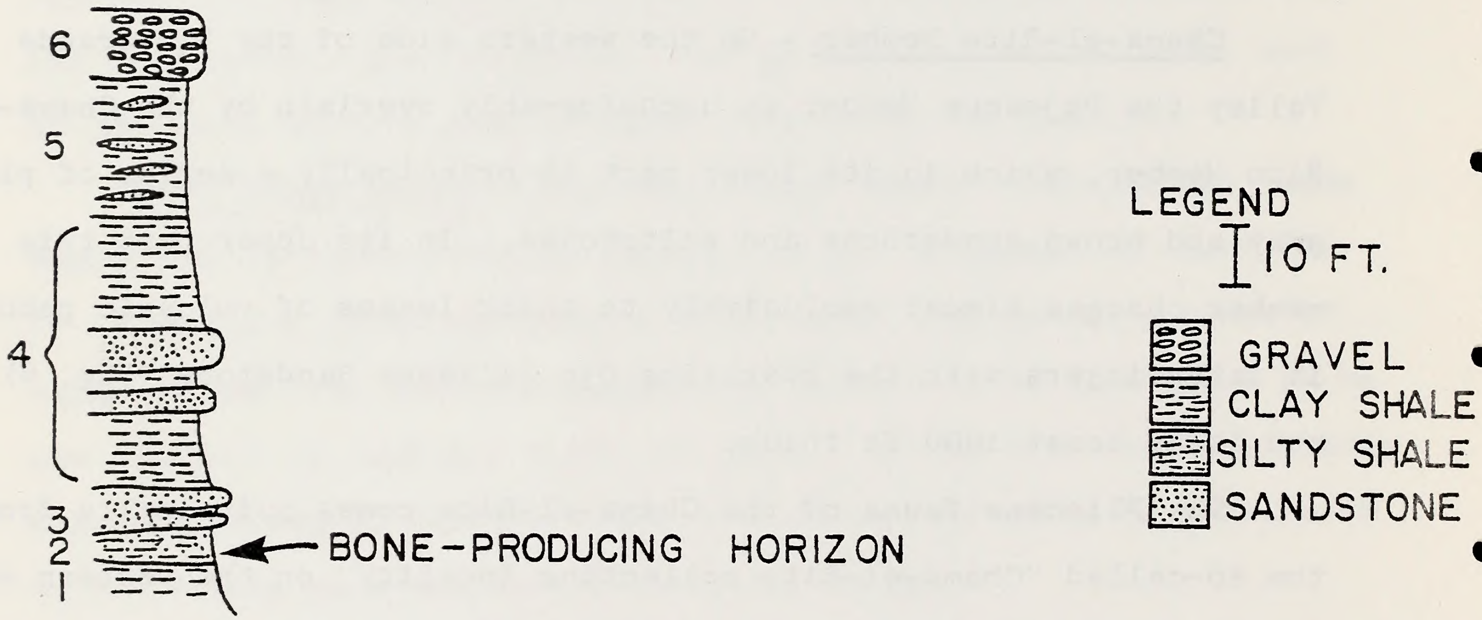
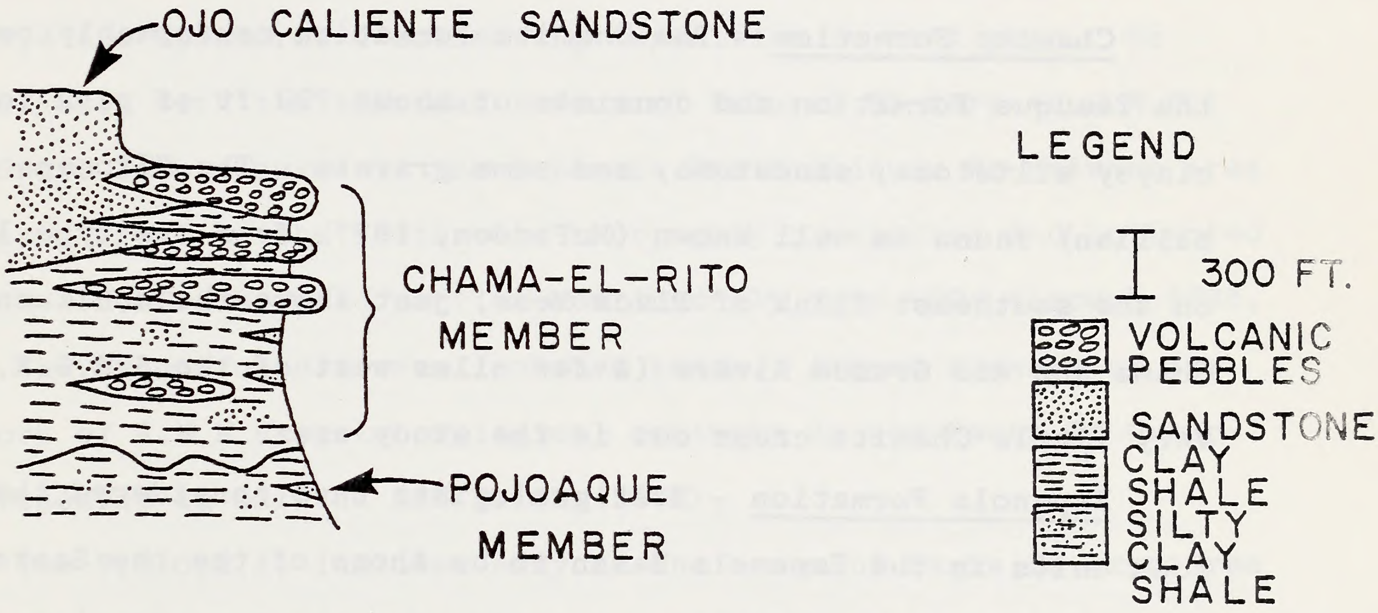


FIGURE 6. Schematic illustration of the lithology and stratigraphic relationships of the Cham-el Rito and Ojo Caliente Members of the Tesuque Formation.



bedding indicative of its aeolian origin. It also appears to be virtually devoid of fossils. Galusha and Blick noted that "Fossils are rare in the Ojo Caliente Sandstone; only in the Fio del Oso collecting locality (not in the S.R.G.R.A.) were significant numbers of specimens found. These fossils came from the lowest 200 ft of the member in this locality". (1971, p. 69). The type locality of the Ojo Caliente Sandstone is a large area between the Ojo Caliente River, Chama River and El Rito Creek, and is within the S.R.G.R.A.

Chamita Formation - The Chamita Formation conformably overlies the Tesuque Formation and consists of about 700 ft of pink to buff clayey siltstone, sandstone, and some gravels. The Pliocene (Hemphillian) fauna is well known (McFadden, 1977) from the type locality on the southeast flank of Black Mesa, just above the confluence of the Chama and Rio Grande Rivers (a few miles west of the S.R.G.R.A.). Very little Chamita crops out in the study area.

Espanola Formation - Most geologists have considered the uppermost rock units in the Espanola Basin to be those of the the Santa Fe Group or Quaternary gravels and tuffs like the Puye Conglomerate and Bandelier Tuff. However, Galusha and Blick also applied the name Espanola Formation to loess-like very fine sands, silts and clays that crop out as erosional remnants throughout the study area. The type section of the Espanola Formation is within the Espanola division of the study area just east of Santa Cruz. We have been able to recognize the same loess-like sands as far away from the type locality as Ojo Caliente and thus are willing to accept the Espanola Formation as a valid rock stratigraphic unit. On the whole the formation is not very fossiliferous, although Galusha and Blick reported fragmentary fossils referable to Equus, Bison, and ?Camelops.

SANTA FE GROUP PALEONTOLOGY

Introduction

Vertebrate fossils from the Santa Fe Group were first collected and studied by Cope in the 1870's. Most of his collections, which included many new species, were from the Pojoaque Bluffs area just west of the Espanola division of the S.R.G.R.A. A copy of pertinent parts of Cope's field notes was made by Galusha some years ago, and is included in Appendix 2 . Little paleontological activity followed Cope's efforts until Childs Frick became interested in these fossils in 1924 and sponsored a collecting expedition in that year. In association with the American Museum of Natural History (A.M.N.H.) all Santa Fe exposures in the Espanola Basin-Abiquiu Re-entrant area and many areas to the south were thoroughly prospected and collected by A.M.N.H./Frick field parties continuously from 1924 through 1965, with the exception of seven isolated years. A good summary of the history of A.M.N.H. paleontological activity in the Santa Fe Group is presented in Galusha and Blick (1971).

The S.R.G.R.A. includes many of the areas of Santa Fe exposures that were collected repeatedly by the A.M.N.H. over their long period of activity in the area. In the discussions below, the tremendous amount of locality and paleontological information resulting from A.M.N.H. work is analyzed in several ways that indicate the scope and general results of the work. The data is summarized in several tables (Tables 3-8) that appear at the end of this section. This data is the most comprehensive that can be assembled under present circumstances, but is certainly not complete.

Locality Information. The locality list (Table 3) for the Santa Fe Group includes *all* localities in the Espanola Basin from which fossils have been collected; sites within the S.R.G.R.A. are indicated by the symbol ⊕. We do not limit the locality list to those within the S.R.G.R.A. for several reasons: 1) No complete locality list was in existence; the construction of this one may prove useful to future workers, 2) Fossils present at sites immediately outside the B.L.M. areas would in some cases suggest the presence of the same taxa inside those areas, even if they had not been reported, and 3) A significant number of localities were so vague that they could have been either within or outside of the S.R.G.R.A.; we did not wish to omit any possibilities. In addition to the Espanola Basin, three other areas of Santa Fe badlands in central New Mexico - Jemez, Ceja del Puerco and Gabaldon - have yielded significant vertebrate fossils, but these are entirely outside of the present B.L.M. study area and are not considered here.

The locality data varies in its detail. In the 1920's, locality information was generally rather vague. In the 1930's and 1940's it became more accurate with respect to specific washes, arroyos, grant boundaries and other landmarks, and in the 1950's sites were designated according to townships, ranges and sections for the first time. Accurate location of sites was facilitated by the publication of 7½ minute topographic maps for much of the Espanola Basin by the U.S. Geological Survey in the early 1950's. Because of these factors, some of the sites on the locality list may overlap, with a well-defined site possibly being within a general area that might have been designated several decades before. Many of the earlier less precise localities could be further refined by searching field books kept by the leaders of Frick/A.M.N.H. collecting parties for more detailed information about where certain specimens were found. Indeed, much precise locality and stratigraphic information was unavailable to or not interpretable by us; suggestions for further study of these data sources are in our recommendations, and in Appendix 3.

The locality information presented in Table 3 has been assembled from several sources: 1) records of materials shipped to the A.M.N.H. from the field over the years, 2) locality cards on file at the A.M.N.H., 3) catalogue cards for A.M.N.H. specimens, 4) publications on Santa Fe Group fossils, and 5) examination of catalogued and uncatalogued specimens and accompanying locality data in the A.M.N.H. and Smithsonian Institution.

In Table 3, some closely spaced localities have been grouped under a general heading; the member or formation represented at each locality is indicated in parentheses after the locality reference. We tabulated 352 total fossil sites in the Santa Fe Group exposures extending from near Santa Fe north to the Ojo Caliente area. Of these sites, 131, or 37% are entirely or partly within the S.R.G.R.A. The localities in Table 3 are arranged roughly geographically from south to north.

Information on Existing Collections. Collections of Santa Fe fossils made by a succession of Frick collectors since the 1920's are housed in the Frick Wing of the A.M.N.H. The collections are somewhat difficult to deal with as a whole because the amount and type of information available, and the degree of attention that has been focussed on the collections varies considerably from group to group. Some specimens are still packed in the boxes that were received from the field crews, and the fossils have yet to be examined (Table 4. Only about 25-30% of the total specimens obtained from field work have been cataloged into the A.M.N.H. collections, and some that are cataloged are not yet represented in a systematic card file, making information about them difficult to efficiently retrieve. Some specimens that have been curated and studied have not been cataloged, and some specimens that have been cataloged have not been curated, identified or studied. This situation reflects the enormous number of specimens [illegible] and the always limited number of trained specialist available to work with them.

Study of the Santa Fe Group vertebrates has been irregular. Cope (1874) described many species from exposures around Espanola, but his descriptions were generally based on incomplete remains, and some of the taxa he established are not recognizable today. Published reports exist for Hemicyon, a carnivore (Frick, 1926a), mastodonts

(Frick, 1926b, 1933), horned ruminants (Frick, 1937), oreodonts (Schultz and Falkenbach, 1940, 1941, 1947, 1949, 1968), some camels (Frick and Taylor, 1968, 1971) and edentates (Hirshfeld and Webb, 1968). Groups currently being studied are canids, rodents including especially, beavers, some camels, and Pojoaque Member microvertebrates. Rhinoceroses, peccaries, insectivores, rabbits and horses have generally not been studied intensively. In addition, the need for revision of some of the earlier published works is recognized.

In view of the above considerations, a complete faunal list for the Santa Fe Group is impossible to assemble at the present time. Available information about the geographic and stratigraphic distribution of Santa Fe faunas is presented in a Locality-Faunal list (Table 3), and a Stratigraphic-Faunal list (Table 5).

The Locality-Faunal list summarizes the fossils found at each locality. In the left column for each locality is a list of material shipped to the A.M.N.H. from New Mexico since 1942, taken from shipping invoices. We arbitrarily chose 1942 as the beginning of this tabulation because that was when T. Galusha assumed leadership of the field parties and began to provide more accurate paleontologic, stratigraphic and site location information. The fossils in the left column were identified in the field, and identifications are usually general and in some cases may be inaccurate. To obtain a relative measur of the quantity of fossils each site produced, we tabulated the type and amount of each taxon reported from each locality. Types of remains are indicated by C = cranial, PC = postcranial, D = teeth, H = horns, PSk = partial skeleton, Sk = complete skeleton. Each C and PC includes a collection of that type of material numbering from one to perhaps ten individual bones or bone fragments. Our impression is that on the average each single C or PC designation suggests about 3-5 bones, and each PSk at least a dozen bones. If one is so inclined, a gross estimate of the total amount of fossil bones collected since 1942 at each site could be made (see Table 6). More fossils were collected before 1942 than afterwards, and we have summarized this information in somewhat less detail in Table 7.

In addition to generalized faunal lists based on field identifications, we have also included a list (right column, Table 3) of all taxa that have been studied or identified in more detail. Included here are taxa described or reported in the published literature, and other taxa which have received detailed attention in the past. The nomenclature of some groups appearing in these lists may be obsolete; with few exceptions we did not modernize the taxonomy. This list is a summary of what is known currently; it is by no means complete. We did not examine every specimen from every locality, nor did we attempt to identify previously unidentified or uncataloged material. Moreover, only a moderate amount of material shipped from New Mexico has been thoroughly studied and authoritatively identified; un-named new taxa are undoubtedly present in the AM.N.H. collections (verbal communication, B. Taylor, 1978). Finally, the detailed list of taxa in the right column of Table 3 relate to specimens collected before, as well as after, 1942; the field lists in the left column apply only to material collected from 1942 .

Some taxa in the A.M.N.H. collections are identified with manuscript names that have not appeared in the literature. Some of these names are synonymous with existing names; others represent new taxa to be described in the future. In consultation with A.M.N.H. paleontologists, we decided that use of manuscript names in this report would be inappropriate; the taxa involved are designated with general names.

In Table 3, the symbol ♦ indicates a taxon for which the type specimen came from the locality indicated, and the symbol ✱ designates a taxon that has been illustrated in the published literature. The sequence of groups in the lists is always camels, deer and antelopes, oreodonts, peccaries, horses, rhinos, proboscideans, edentates, carnivores, insectivores, rodents, beavers, rabbits and non-mammals.

The Stratigraphic Faunal List (Table 5) combines all taxa reported from all localities into a comprehensive summary, and indicates their range throughout the units that compose the Santa Fe Group in the Espanola Basin. All of the units indicated on this list are exposed within the S.R.G.R.A., but not every species on the list has been reported from localities within the S.R.G.R.A.

Scope of Previous Collections. A third body of information on the Santa Fe Group fossils is presented in summaries of the type and amount of material collected from the Espanola, Jemez and Ceja del Puerco areas. Though the latter two areas are entirely outside of the S.R.G.R.A., some information on these collections is included for comparative purposes. Table 8 indicates the numbers of partial and complete skeletons excavated by the A.M.N.H., broken down into Early (1924-1941) and Later (1942-1965) collections. In general, fossil vertebrate skeletons are much rarer than isolated bones, and the number and diversity of partial and complete skeletons found in an area provides a significant measure of the richness and paleontologica importance of the area. The definition of a partial skeleton used here is a collection of entirely or partially articulated bones including normally the skull, part of the vertebral column and several major limb bones - representing one animal.

Table 6 summarizes the total amount of other skeletal parts for each major group of animals. As mentioned above, this tabulation includes only those collections made after 1941, after Galusha assumed supervision of field operations. Many areas of the Espanola Basin that his parties collected from had been collected previously, so this data reflects material from both new sites and some that had been essentially "mined out". The great quantity of fossil vertebrate material collected after 1941 testifies to the tremendous productivity of the Santa Fe Group, because the extensive Early collections had undoubtedly depleted many locations. According to Galusha (verbal communication, October, 1978), it was the custom of A.M.N.H. collecting parties to recollect good sites year after year, to harvest any fossils that might have eroded out between successive field seasons. It is noteworthy in this regard that the collecting activities of the A.M.N.H. ceased in 1965, and little collecting from the Santa Fe Group has been done since then.

TABLE 3. Summary of specific and general fossil localities reported by American Museum of Natural History collectors in Santa Fe Group exposures in the Espanola Basin. This locality list includes areas around as well as within the S.R.G.R.A. For each locality there are two lists of the fossils collected there. The list on the left refers to fossils identified in the field, and is taken from invoices for material shipped from the field to the A.M.N.H. since 1942. The list on the right refers to material that has been studied or identified, at any time.

1. Tesuque Pueblo Grant (general) (Skull Ridge)

camel - 19C, 12PC, 1 PSk
Michenia - 1C
deer - 3C, 3PC, 1D, 1H
oreodont - 1PC
horse - 4C, 6PC, 5D, 1 PSk
rhino - 4C, 1PSk
carnivore - 5C, 3PC
beaver - 1C, 1PC

Miolabis sp.
Michenia sp.
"Un-named new camel taxon, 1"
"Un-named new camel taxon, 2"
Protolabinae
Aepycamelus spp.
◆*Meryceros* (*Submeryceros*) *minor*
merycodont
Rakomeryx sp.
Equinae
Aphelops sp.
Peraceras (small species)
Teleoceras sp.
Pseudaelurus sp.
Canidae new genus
Leptocyon vafer
Carpocyon sp.
Cynarctoides sp.
Prohyaena sp.
Tomarctus confertus
"T." kelloggi
Amphicyon ingens
Mylagaulus

2. Tesuque Pueblo Grant, near center, sec. 9, T 18 N, R 9 E (Skull Ridge)

camel - 1 C
horse - 1 C, 2 PC

Equinae

3. Tesuque Pueblo Grant, W side, sec. 7, T 18 N, R 9 E (Pojoaque or Skull Ridge)

camel - 1 C, 3 PC

"*Tomarctus*" *kelloggi*

4. Tesuque Pueblo Grant, "near Tesuque north fence" and just N of the fence, sec. 34, T 19 N, R 9 E (Skull Ridge)

horse - 1 C

Michenia sp.
"*unnamed* new camel taxon 1"
Tomarctus confertus
Equinae

5. Jacona Grant; 100 yds SW of 4 ½ M stake on W Tesuque Grant Boundary (Pojoaque or Skull Ridge)

horse - 1 C

Equinae

6. Jacona Grant, S end (Pojoaque)

camel - 1 PC
deer - 2 H
Cranioceras - 1 C
merycodont - 2 C, 1 PC, 2 H
horse - 1 PC
rhino - 1 PC
mastodon - 1 PC
Canidae - 1 C
rodent - 1 PC

7. Jacona Grant, E boundary, in Jacona Wash (Pojoaque)
included are: a) head of Jacona Wash; b) Nambe drainage system

camel - 3C, 3C(b), 4 PC,
3PC(b), misc
deer - 1C, 2H, 2H(a)
merycodont - 1C, 1H
horse - 1C, 2PC, 1 PC(a)
rhino - 1PC
mastodon - 3PC, 1D, 1C(b)
carnivore - 2C, 4PC, 1 PC(b)
rodent - 1C
beaver - 3C
gastropods
cast of wasp's nest

8. Jacona Grant, Jacona microfossil quarry, in Jacona Wash (Pojoaque)

camel - 3C, 1PC
deer - 2 PC, 4H
Ramoceras - 5H
merycodont - 6C, 1H
Cranioceras - 2C
Blastomeryx - 1C
Peramoceras - 1H
Longirostromeryx - 4C
Hypohippus - 1C
horse - 1C, 6PC
rhino - 2C
carnivore - 1PC
Soricidae - 1C
Cf. Amphechinus - 4C, 1D
Scalapoides? - 1C
Domninoides - 1PC
rodent - 81C, 1PC, misc.
rabbit - 1C
bird - 1PC, misc.
Reptilia - misc.
turtle - 2 shell
Amphibia - misc.
gastropods

Cranioceras teres
Longirostromeryx blicki
Soricidae
Cf. Amphichinus
Teleoceras sp.

9. Jacona Grant, Pojoaque Bluffs (Pojoaque)

camel - 3C, 3PC
Protolabinae - 1C
deer - 2C, 4H
merycodont - 1C, 1PC
horse - 1PC
rhino - 3PC, 1C
mastodon - 2C
carnivore - 1C, 2PC
Prohyaena - 1 PSk
rodent - 1PC
beaver - 1C
turtle - 1PC
coprolites

Protolabinae
Michenia sp.
Longirostomeryx sp.
Leptocyon vafer
Carpocyon sp.

10. Cuyumunque (Skull Ridge)

Procamelus sp.
* *Rakomylus raki*
Aepycamelus sp.
Homocamelus sp.
Miolabis sp.
"unnamed new camel taxon 1"
"unnamed new camel taxon 2"
* *Longirostomeryx blicki*
* *Meryceros ?(Submeryceros) minor*
* *M. ?(S.) minimus*
Meryceros crucensis
Equinae
Teleoceras sp.
Amphicyon ingens
A. ?sinapius
Leptocyon vafer
Tomarctus sp.
T. confertus
"T." kelloggi
Mylagaulidae

11. 4 miles S of Cuyumunque (Skull Ridge?)

Aepycamelus sp.

12. 3 miles from Cuyumunque, left side of road to Santa Fe (Skull Ridge?

"Tomarctus" kelloggi

13. SE Cuyumunque (Skull Ridge)

horse - 1C

14. .5 to 1.0 mile E of Cuyumunque (Skull Ridge ?)

rhino - 1PC

"Unnamed new camel taxon 2"
"Tomarctus" kelloggi

15. Due W of Camel Rock (Skull Ridge)

camel - 1C
horse - 1C

Peraceras (small species)

16. East Cuyumunque; Skull Ridge and non specific (Skull Ridge)

camel - 2PC
deer - 2C
oreodont - 1C
horse - 1PC, 1D
wood

Homocamelus sp.
Aepycamelus sp.
Aepycamelinae
Miolabis sp.
Blastomeryx sp.
Meryceros crucianus?
M. ?(S.) minor
Ustatochoerus sp.
Teleoceras sp.
Pseudaelurus aeluroides

17. East Cuyumunque; just N of Tesuque Grant boundary (Nambe or Skull Ridge)

carnivore - 1C

18. East Cuyumunque, ½ mile E of highway and 1 mile N of Cuyumunque (Skull Ridge)

camel - 2PC
rhino - 2PC

19. East Cuyumunque Wash; SE side (Skull Ridge)

camel - 1PC

*_Rakomylus raki_

20. East Cuyumunque Wash; SW side (Skull Ridge)

Protolabis - 1PC
wood

21. East Cuyumunque; NW flowing tributary, sec. 27, T 19 N, R 9 E (Skull Ridge). Includes several other localities in sec. 27: a) NE¼ sec. 27, b) head of S tributary, sec. 27, c) washes N of boundary washes, sec. 27

camel - 7C, 3PC, 1 PSk
horse - 1C
rhino - 1C, 2PC
carnivore - 4C, 1PC
Pseudaelurus - 1C

Homocamelus sp.

22. East Cuyumunque; 150 yards N of ¼ sec. stake at sec. 15 & 16, T 19 N, R 9 E (Skull Ridge)

camel - 1C, 1PC

23. East Cuyumunque; 100 yards S of ¼ sec. stake at sec. 15 & 16, T 19 N, R 9 E (Skull Ridge)

camel - 1C

24. East Cuyumunque; tributary on Nambe Pueblo Grant (Skull Ridge?)

horse - 1 PSk

Pseudaelurus sp.

25. East Cuyumunque; N of drainage divide between E. Cuyumunque and Nambe Washes (Skull Ridge or Nambe)

camel - 1C, 2PC
oreodont - 1C

Aepycamelinae, new? taxon

26. East Cuyumunque; SE of Pojoaque Pueblo Grant boundary fence (Skull Ridge)

Rakomylus - 1C

27. East Cuyumunque; E boundary of Pojoaque Pueblo Grant (Skull Ridge). Includes a) ¼ mile E of grant boundary

Alticamelinae - 1PC(a)
Aepycamelinae, new? taxon - 1C, 1PC
carnivore - 1C

Aepycamelinae

28. East Cuyumunque; 20' W of boundary of Pojoaque Pueblo Grant (Skull Ridge)

Aepycamelinae, new? taxon

29. Arroyo Ancho; believed sec. 29, T 19 N, R 9 E and surrounding area (Skull Ridge)

camel - 7C, 3PC, 1D, 1 PSk
deer - 2C, 1H
horse - 2C, 1PC, 1D
carnivore - 1C
rodent - 2C

Miolabis sp.
Aphelops sp.

30. Arroyo Ancho; western limit (Skull Ridge or Pojoaque)

camel - 2C
rhino - 1C

31. Arroyo Ancho; W side (Skull Ridge or Pojoaque)

merycodont - 1PC
rhino - 1C
carnivore - 1C

32. Arroyo Ancho; area E of (Pojoaque)

camel - 2C
Mylagaulis - 1C

Homocamelus sp.
"unnamed new camel taxon 1"

33. Between Arroyo Ancho and Rio Tesuque, sec. 32, T 19 N, R 9 E, Tesuque Pueblo Grant (Skull Ridge)

camel - 2C, 3PC
small camel - 1C
horse - 1PC
rhino - 1PC
Amphicyon - 1C
mustelid - 1C

Miolabis sp.
Tomarctus sp.
T. confertus

35. Arroyo Ancho side of ridge between Arroyo Ancho and Rio Tesuque (Skull Ridge)

Aepycamelinae, new? taxon

36. Between Arroyo Ancho and Rio Tesuque, sec. 5, T 18 N, R 9 E (Skull Ridge)

camel - 4PC
deer - 2 PC
horse - 3PC
mustelid - 1C

Protolabinae

37. Between Arroyo Ancho and W boundary of Tesuque Grant, sec. 6 T 18 N, R 9 E, Tesuque Pueblo Grant (Skull Ridge)

rhino - 1C

38. SE¼ NE¼ sec. 8, T 18 N, R 9 E, Tesuque Pueblo Grant (Skull Ridge)

carnivore - 1C

39. Arroyo Ancho Prospect, NW¼ sec. 9, T 18 N, R 9 E (Skull Ridge)

camel - 13C, 3PC
Protolabis - 1PC
horse - 7C
carnivore - 1C
Amphicyon - 1C, 4PC
beaver - 1C

Amphicyon ingens
Protolabinae

40. Next canyon N of Arroyo Ancho Prospect, Tesuque Pueblo Grant (Skull Ridge)

camel - 1C

41. SW¼ sec. 9, T 18 N, R 9 E, Tesuque Pueblo Grant (Skull Ridge)

camel - 1C, 1PC

42. SE$\frac{1}{4}$ sec. 9, T 18 N, R 9 E, Tesuque Pueblo Grant (Skull Ridge)

carnivore - 1C

43. sec. 16, T 18 N, R 9 E, Tesuque Pueblo Grant (Skull Ridge)

camel - 1PC
deer - 1C
horse - 1C
mastodon - 1C

44. West Cuyumunque Wash, including especially the W side (Pojoaque)

camel - 7C, 5PC, misc.
Protolabinae - 4C, 2PC
deer - 1C, 3PC
horse - 3 PC, 1 PSk
mastodon - 1 PC
carnivore - 1 PC, 1D
Amphicyon - 2 PC
Perognathus - 1C
bird tracks
turtle - 1PC
worm trails
wood

Protolabis heterodontus
"unnamed new camel taxon 1"
"unnamed new camel taxon 2"
Aepycamelus sp.
Homocamelus sp.

Protolabinae
Miolabis sp.
merycodont
Meryceros ?*(Submeryceros)* *minor*
Ramoceras ramosus
Teleoceras sp.
Peraceras crassus
P. (small species)
Tomarctus confertus
Leptocyon vafer
Amphicyon sinopius
Bassariscus sp.
Plionictis sp.
cf. *Perognathus*
Mylagaulidae?

45. West Cuyumunque; right fork of tributary wash (Pojoaque?)

camel - 1PC
deer - 1C

46. West Cuyumunque; E side, 1/3 mile S of Pojoaque Grant fence (Pojoaque)

merycodont - 1H

47. West Cuyumunque; E side, N of Pojoaque Grant fence (Pojoaque)

camel - 1PC

Tomarctus confertus
Mylagaulidae

48. West Cuyumunque, E side, 100 yards N of S boundary of Pojoaque Grant (Pojoaque)

deer - 2H

49. West Cuyumunque; head of E fork, on Pojoaque Grant (Pojoaque)

camel - 1C

"unnamed new camel taxon 2"

50. Pojoaque Pueblo Grant (unspecific) (Pojoaque and Skull Ridge)

camel - 2C, 3PC
deer - 1PC, 4H
horse - 2PC, 1D
rhino - 2PC
carnivore - 1PC

Cosoryx ilfonsensis
Pseudaelurus sp.

51. Pojoaque Bluffs, from Jacona to Pojoaque Grants (Pojoaque)

oreodont - 1C

52. Pojoaque Pueblo Grant, near northern boundary (Pojoaque and Skull Ridge). Includes a) 50 yards N of N boundary, b) SW¼ sec. 30, T 20 N, R 9 E, c) ¼ mile N of N boundary, d) NE¼ sec. 33, e) just SW of NE corner stake of Grant, f) ¼ mile S of Santa Clara Grant in Pojoaque Grant

camel - 1C, 1PC, 1C(b), 1C(c)
  2PC(c), 1C(d), 2PC(d)
"unnamed new camel taxon 2"
  1C(e), 1PC(e)
deer - 4C, many H
merycodont - 34C, 7PC
Meryceros - 2C, 11H
Ramoceros - 3H
Brachycrus - 1C(d)
horse - 2PC, 1C(d), 2PC(d)
rhino - 1PC, 1C(a), 1PC(f)
mastodon - 1PC
carnivore - 1C(c)
Leptocyon - 1C
mustelid - 1C
rodent - misc.

Miolabis sp.
Brachycrus sp. (e)

53. Pojoaque Pueblo Grant; wash just E of stake for sec. 29, T 20 N, R 8 E, 1 mile S of N boundary of Pojoaque Grant (Pojoaque?)

horse - 1C

54. Pojoaque Pueblo Grant; 200 yards E of highway (Skull Ridge)

camel - 1PC

55. Pojoaque Pueblo Grant; Nambe side of drainage divide (Skull Ridge?)

camel - 1C, 1PC

56. Pojoaque Bluffs (unspecified) (Pojoaque) . Most taxa from this locality are from Central Pojoaque Bluffs

Aepycamelus sp.
Protolabis sp.
Ramoceros ramosus
R. marthae
*_R. ramosus quadratus_
merycodont
Longirostromeryx blicki
*_Meryceros crucensis_
M. major
Pseudoparablastomeryx francescit
*_Cosoryx serroensis_
C. major
?_Pseudoceros_
Equinae
Teleoceras sp.
Aphelops sp.
Peraceras (small species)
Acerathini
Ustatochoerus sp.
U. medius novomexicanus
*_Serridentinus productus_
Prohyaena sp.
Amphicyonidae
Leptocyon vafer
Tomarctus sp.
Aelurodon? haydeni
"_Mustela_" sp.
Plionictis sp.
Eucastor tortus

57. "Below Pojoaque Bluffs" (Pojoaque)

Meryceros crucensis

58. Pojoaque Pueblo Grant; South Pojoaque Bluffs (Pojoaque and Skull Ridge)

camel - 2PC
deer - 2C, 2PC, 1H
merycodont - 1C
Ramoceros - 2C, 5H
oreodont - 1C
horse - 3 PC
carnivore - 1C, coprolite
rodent - 1C, 1PC
beaver - 1C
rabbit - 1PC
bird - 2PC

Michenia sp.
Protolabis spp.
Aepycamelus sp.
Meryceros crucensis
Equinae
Aphelops sp.
Peraceras (small species)
Pseudaelurus sp.
P. marshi?
Tomarctus sp.
Mylagaulidae
Eucastor tortus

59. Lower Pojoaque Bluffs; S and 3/4 mile SE of Round Mountain (Pojoaque)

deer - 1PC, 1H
mastodon - 1C, 1PC
carnivore - 1PC
Carpocyon - 1C
rodent - 1C
beaver - 1C
Misc.

Aepycamelus sp.
Procamelus sp.
Protolabis sp.
merycodont
*Ramoceros ramosus
Meryceros crucensis
Plioceros blicki
Dicotylidae
Equinae
Teleoceras sp.
Peraceras (small species)
*Serridentinus productus
*Ocalientinus ocaliensis
Amphicyonidae
Tomarctus confertus
Prohyaena sp.
Eucastor tortus
Dipoides cf D. planus

60. Lower Pojoaque Bluffs; first wash to enter Rio Grande N of Nambe Creek (Pojoaque)

mastodon - 1C

61. Lower Pojoaque Bluffs; E of central fault, W of Mesilla-San Ildefonso Road (Pojoaque)

camel - 1C, 1PC
horse - 1PC
mastodon - 1C, 1D
Felidae - 1C

62. Lower Pojoaque Bluffs; W of central fault (Pojoaque)

deer - 2H
carnivore - 2PC

Carpocyon sp.

63. "Southwest Pojoaque Bluffs" (Pojoaque)

camel - 4C, 2PC
deer - 4C
oreodont - 1C
rhino - 1C
mastodon - 1C, 1PC, 1D
Prohyaena - 2C
Mylagaulidae - 1C
beaver - 1C

Protolabis sp.
"unnamed new camel taxon 2"
Cosoryx ilfonsensis
Ramoceros ramosus
merycodont
Ustatochoerus sp.
*Ocalientinus ocaliensis
Prohyaena sp.
Mylagaulus sp.

64. "Southeast Pojoaque Bluffs" (Pojoaque)

deer - 3C
merycodont - 1C
Ramoceros - 2H
horse - 1PC, 1D
carnivore - 1C
mustelid - 1C
rodent - 2C
Lepus - 1C

merycodont
Ramoceros ramosus
Prohyaena sp.

65. "Central Pojoaque Bluffs"; unspecified, plus several well defined localities: a) NW¼ SE¼ sec. 36, T 20 N, R 8 E, b) SW¼ SE¼ sec. 36, c) SE¼ sec. 36, d) NW¼ NE¼ sec. 36, e) NE¼ sec. 1, T 19 N, R 8 E (Pojoaque)

camel - 6C, 5PC, 1D
Procamelus sp. - 1C
deer - 5C, 4H
merycodont - 1C
antelope - 1D
Ramoceros - 2H
oreodont - 1C, 2PC
horse - 2PC, 1D
Megahippus - 1C
rhino - 4PC
carnivore - 1C, 2PC, 1 PSk
Canidae - 1PC
Aelurodon - 1C
Pseudaelurus - 1C
"shrew or rodent" - 1 PSk
rodent - 1PC, 2D
Amphichinus - 1C

Procamelus sp.
Aepycamelus sp.
merycodont
Longirostromeryx novomexicanus
Prohyaena sp.
Leptocyon vafer
Sthenictis sp.

66. Central Pojoaque Bluffs; Needle tributary of first large wash between Splinter and Barrancos faults at stake sec. 25 & 36, T 20 N, R 8 E (Pojoaque)

camel - 1C
Ramoceros - 1H
Meryceros - 1H
deer - 1C

67. Central Pojoaque Bluffs; SW¼ sec. 2, T 19 N, R 8 E (Pojoaque)

rhino - 1C, 1PC

68. Central Pojoaque Bluffs, sec. 2, T 19 N, R 8 E (Pojoaque)

camel - 4C, 2PC, 1 PSk
deer - 2H
carnivore - 1C
lizard - 1C

69. Central Pojoaque Bluffs; NW¼ sec. 11, T 19 N, R 8 E (Pojoaque)

deer - 3H
Ramoceros - 1H
rhino - 1PC

70. Pojoaque Bluffs; tributary W of 2nd west Pojoaque fault (Pojoaque)

camel - 1C
carnivore - 2PC

71. Pojoaque Bluffs; S tributary E of 2nd west Pojoaque fault (Pojoaque)

oreodont - 1C

72. SW¼ NE¼ NW¼ sec. 21, T 20 N, R 8 E, Santa Clara Pueblo Grant (Pojoaque)

carnivore - 1C

*73. North (Upper) Pojoaque Bluffs (largely in secs. 24 & 25, T 20 N, R 8 E). Includes "Pojoaque Bluffs, Santa Clara Grant". (Pojoaque)

camel - 1PC
deer - 1C
merycodont - 1C, 1PC, 2H
mastodon - 1D
rodent - 2C, 1PC
Domninoides? - 1C
lizard - 2C

Michenia sp.
Protolabis sp.

"unnamed new camel taxon 2"
Aepycamelus sp.
merycodont
Meryceros crucensis
M. ?(Submeryceros) minor
Ramoceros ramosus
R. r. quadratus
* *R. (Paramoceros) marthae*
Blastomeryx francesca
Cosoryx ilfonsensis
C. major
?*Longirostromeryx blicki*
Plioceros blicki
* *Meryceros major*
Equinae
Peraceras crassus
P. (small species)
Teleoceras sp.
* *Ocalientinus ocaliensis*
Prohyaena sp.
Amphicyon sp.
Leptocyon vafer
Tomarctus sp.
Strobodon sp.
Carpocyon sp.
Pseudaelurus sp.
P. marshi
Sthenictis sp.
"Mustela" sp.
Bassariscus sp.

74. North Pojoaque Bluffs; several specific localities in sec. 25, T 20 N, R 8 E: a) NW¼, b) SE¼NW¼, c) SW¼ SE¼ NW¼, d) Arroyo Madrid, NE¼ SW¼, e) NW¼ SW¼, ⊛f) SW¼ NE¼, g) line between SW¼ & SE¼ (Pojoaque)

camel - 2C, 2PC
deer - 8C, 4PC, 5H, misc.
Meryceros - 1H
oreodont - 1C
mastodon - 1C, 1PC, 1D
rhino - 1C, 2PC
carnivore - 2C, misc.
rodent - 1C, 1PC
wood

Merycoidodontidae

75. North Pojoaque Bluffs, Santa Clara Grant; First wash N of S boundary of grant (probably in sec. 25) (Pojoaque)

camel - 5C, 10PC, 1 PSk
deer - 3C, 2PC, 2H
Meryceros - 1H
Ramoceros - 3H
merycodont - 2PC, 1H
horse - 1PC
Megahippus - 1C
rhino - 3C, 3PC
mastodon - 1C, 1PC
carnivore - 2C, 2PC
Canidae - 1PC

Aepycamelus sp.
Equinae

76. Santa Clara Grant; 2nd wash N of S boundary of grant (Pojoaque)

merycodont - 2C

⊛ 77. Pojoaque Bluffs; E boundary of Santa Clara Grant (Pojoaque)

deer - 1C
rhino - 1PC

78. North Pojoaque Bluffs; about 425 yards N60°E of highest point on bluffs (Pojoaque)

camel - 2C, 4PC
deer - 5C, 1PC, 3H
Ramoceros - 1H
oreodont - 1C, 1PC
horse - 1PC
rhino - 2C
mastodon - 2C
carnivore - 2C
Pseudaelurus - 1C

79. Pojoaque Bluffs, Santa Clara Grant; Mesilla Prospect, SW¼ NE¼ sec. 27, T 20 N, R 8 E (Pojoaque)

camel - 2C, 1PC
deer - 3C
merycodont - 4C, 1PC, 6H
Meryceros - 1C, 5H
carnivore - 1C, 3PC
rodent - 5C, 1PC

80. West side, North Pojoaque Bluffs (Pojoaque)

Protolabinae
Protolabis sp.
Ramoceros ramosus
R. (Paramoceros) marthae

⊛ 81. East slope, North Pojoaque Bluffs (Pojoaque)

Procamelus sp.
Meryceros crucensis

⊛ 82. East Pojoaque Bluffs (Pojoaque)

Aepycamelus sp.
Ramoceros ramosus
Prohyaena sp.

83. West Pojoaque Bluffs (Pojoaque)

merycodont
Meryceros crucensis
Ramoceros ramosus
R. (P.) marthae
Peraceras (small species)
Equinae
Tomarctus sp.
Leptocyon vafer
Prohyaena sp.
Mylagaulus sp.
Eucastor tortus

84. North of Santa Clara River and surrounding area (Chamita)

Meryceros crucensis
◆ ?*Longirostromeryx blicki*
Cosoryx major
C. ilfonsensis
Ustatochoerus profectus espanolensis
U. skinneri santacruzensis
Leptocyon vafer
Prohyaena sp.

85. Santa Clara Canyon (Pojoaque? and Chamita)

deer - 1PC
mastodon - 1D
Canidae? - 1C

Procamelus sp.
*?_Longirostromeryx blicki_
_L._ sp.
Meryceros crucensis
Cosoryx ilfonsensis
Blastomeryx francesca
merycodont
Ustatochoerus profectus espanolensis
Mylagaulus
Eucastor tortus

86. Upper Santa Clara Canyon (Chamita)

camel - 1PC

Megatylopus sp.

87. Santa Clara Canyon, S side (Chamita)

camel - 1PC
deer - 1H

Teleoceras sp.

88. S of Santa Clara Canyon (Pojoaque? or Chamita)

carnivore - 1C

89. First wash S of Santa Clara Canyon (Pojoaque)

Alticamelinae - misc.

90. Santa Clara; NE of Round Mountain Quarry (Pojoaque)

carnivore - 1C

91. Santa Clara; 3rd promontory N of Santa Clara Canyon (Chamita)

mastodon - 1D
?sloth - 1C

Pliometanastes sp.

92. Santa Clara Quarry (Pojoaque or Chamita)

merycodont
Meryceros crucensis

93. San Ildefonso (nonspecific) (Pojoaque and Chamita)
West of fault and extending north of
Sacred Spring to Battleship
Mountain.

"unnamed new camel taxon 2"
Aepycamelus sp.
Procamelus sp.
merycodont
✱ *Meryceros crucensis*
✱ *Cosoryx*?
◆ *C. ilfonsensis*
C. ilfonsensis?
✱ *Plioceros blicki*
Longirostromeryx novomexicanus
Ustatochoerus sp.
Equinae
Peraceras crassus
P. (small species)
Teleoceras sp.
✱ *Serridentinus productus*
?Amphicyonidae
Leptocyon vafer
L. sp
Tomarctus sp.
Prohyaena sp.
Aelurodon sp.
Carpocyon sp.
?*Hemicyon*
Bassariscus sp.
"*Mustela*" sp.
◆ *Pliogale*? *nambianus*
Mylagaulidae

Eucastor tortus

94. San Ildefonso, Rodent Pocket; N side of large wash 1 mile N
of Sacred Springs and E of Sacred Springs fault (Pojoaque?)

merycodont - 1C
Cosoryx -1H
Longirostromeryx - 1C
carnivore - 1PC
rodent - 15C, 1PC, 1D
Dipodomys cf *D. hermanni*
bird - 1PC
turtle - shell

Dipodomys cf *D. hermanni*

95. San Ildefonso; E of Sacred Springs fault (Pojoaque)

camel - 1PC
merycodont - 1C, 1PC, 1H
Pliohippus - 1C, 1PC
Hypohippus - 1C
carnivore - 1PC
mustelid - 1C
Osteoborus - 1C
rodent - 1PC

Equinae

96. San Ildefonso Pueblo Grant; wash E of E boundary fence (Pojoaque)

camel - 1C
insectivore - 1C

97. San Ildefonso; W & SW of Sacred Spring and W of Sacred Spring fault (Chamita)

camel - 1PC
deer - 5C, 3PC, 1H
Cosoryx - 1H

Aelurodon sp.

98. Battleship Mountain (Pojoaque or Chamita)

Aepycamelus sp.
◆ Trilophodon (Tatabelodon) riograndensis

99. Battleship Mountain, W of Battleship fault, near San Ildefonso locality (Chamita?)

camel - 1C, 2PC
carnivore - 1C, 1PC

* Plioceras blicki
Canis davisi
Prohyaena sp.

100. S of Battleship Mountain (Chamita)

deer - 1C
horse - 1C

Equinae
Aelurodon sp.

101. Round Mountain Quarry; 2 miles NW of Round Mountain (Chamita)

Protolabis sp.
Hemiauchenia vera
* Ramoceros (Paramoceros) marthae
* Pseudoceros klausi
Cosoryx sp.
◆ C. (Subcosoryx) cerroensis
Merycoidodontidae
Prosthemnops (Dicotylidae)
Teleoceras sp.
Aelurodon sp.
A.? haydeni
Prohyaena sp.
Leptocyon sp.
Bassariscus sp.
Sthenictis sp.
Mylagaulidae
Equinae

⊛102. Santa Cruz (general area) (Pojoaque and Skull Ridge)

camel - 2PC

"unnamed new camel taxon 2"
Procamelus sp.
Aepycamelus sp.
Cranioceros teres
Blastomeryx francesca
◈ Pseudoparablastomeryx francescita
◈ Plioceros blicki
◈ Cosoryx major
C. ilfonsensis
◈ Meryceros cruciensis
◈ M. major
◈ M. (Submeryceros) crucianus
◈ Longirostromeryx novomexicanus
✳ Ramoceros ramosus
◈ R. r. quadratus
◈ R. (Paramoceros) marthae
merycodont
Longirostromeryx blicki
L. sp.
Ustatochoerus medius novomexicanu
◈ U. profectus espanolensis
Equinae
Aphelops sp.
Teleoceras sp.
✳ Ocalientinus ocaliensus
◈ Trilophodon cruzensis
✳ T. pojoaquensis
◈ Trobelodon taoensis
◈ Megabelodon joraki
Pseudaelurus sp.
P. marshi
Tomarctus sp.
Carpocyon sp.
Prohyaena sp.
Strobodon sp.
"Tomarctus" kelloggi
Amphicyonidae
Leptocyon vafer
Bassariscus sp.
Mustela?
Sthenictis sp.
Plionictis sp.
Metechinus amplior
M. nevadensis
Mylagaulus sp.

Promylagaulus novellus
E. cf. E. planus
"Dipoides" williamsi

103. West edge of Santa Cruz area (Pojoaque?)

camel - 1C, 2PC
deer - 22C, 2PC, 3H
oreodont - 1C
mustelid - 1C
rodent - 5C, 1PC
snake? - 1C

Ustatochoerus profectus espanolensis
Tomarctus sp.
Strobodon sp.

⊛ 104. Santa Cruz - sec. 6, T 20 N, R 9 E (Pojoaque)

Prohyaena - 1 PSk

⊛ 105. North side, Santa Cruz Wash (Pojoaque or Skull Ridge)

"unnamed new camel taxon 2"

⊛ 106. Santa Cruz, First Wash (Pojoaque). Includes ⊛a) NE¼ SW¼ sec. 31 T 21 N, R 9 E

camel - 1C, 5PC
deer - 30C, 19H
Ramoceros - 3H
Meryceros - 2H
Cranioceros - 1C
horse - 2C, 1PC, 1D
Hypohippus - 1PC
mastodon - 2D
Aelurodon - 1C
carnivore - 3C, 1PC
Prohyaena - 1C
mustelid - 1C
rodent - misc.
beaver - 1C, 1C(a), 1 PSk(a)
invertebrates

Procamelus sp.
Protolabis sp.
Aepycamelus sp.
merycodont
✱*Ramoceros ramosus*
R. r. quadratus
R. (P.) marthae
Meryceros major
M. crucensis
Cosoryx ilfonsensis
C. major
Plioceros blicki
Blastomeryx francesca
✱?*Longirostromeryx blicki*
Ustatochoerus sp.
◆*U. californicus raki*
◆*U. medius novomexicanus*
◆*U. skinneri santacruzensis*
Equinae
Teleoceras sp.
Pseudaelurus marshi
Leptocyon vafer
Tomarctus sp.
Prohyaena sp.
Strobodon sp.
Carpocyon sp.
Eucastor tortus

⊛ 107. Santa Cruz, Second Wash (Pojoaque)

camel - 1C
deer - 2C, 6PC, 2H
Ramoceros - 1H
horse - 2C, 1PC
carnivore - 2PC
Domninoides - 1C
rodent - 12C, 2PC
Mylagaulus - 1C
rabbit - 1C

Protolabis sp.
Aepycamelus sp.
merycodont
Meryceros crucensis
Cranioceros teres
Longirostromeryx sp.
?*L. blicki*
Equinae
Teleoceras sp.
Peraceras (small species)
Pseudaelurus sp.
P. cruensis
P. (*Microlurus*) *stouti*
Leptocyon vafer
Tomarctus sp.
Prohyaena sp.
Cf. *Amphichinus*
Mylagaulidae
Eucastor tortus

⊛ 108. Santa Cruz, Third Wash. Includes Rodent Prospect, on W side of wash about 1.5 miles above point where wash crosses Chimayo Road (a)⊛ and Near divide with Second Wash (b)⊛ (Pojoaque)

camel - 1PC
deer - 5C, 1PC
Alticornis? - 1H
horse - 1PC
Hypohippus - 1C
mastodon - 1D
carnivore - 3C, 1PC, 1C(b)
rodent - 2C, 1PC, 20C(a)
beaver - 1C

Protolabis sp.
"unnamed new camel taxon 2"
Aepycamelus sp.
merycodont
Longirostromeryx sp.
Equinae
Leptocyon vafer
Prohyaena sp.

⊛ 109. Santa Cruz, W fork of Third Wash (Pojoaque)

camel - 1C, 1PC

⊛ 110. Santa Cruz, between Fourth and Fifth Washes (Skull Ridge)

Protolabis sp.

⊛ 111. Santa Cruz, Fourth Wash (general), and ridges between middle and east forks (Pojoaque or Skull Ridge)

rabbit - 1C

Aepycamelus sp.
Peraceras (small species)
Teleoceras sp.

⊛ 112. Santa Cruz, Seventh Wash (Skull Ridge)

carnivore - 1C

⊛ 113. About 200 yards NW of corner sec. 26,27,34, & 35, T 21 N, R 9 E (Skull Ridge)

camel - 1C

⊛ 114. Between Arroyo Seco Wash and Santa Cruz River. Includes ⊛a) South of Santa Cruz River (Pojoaque and Skull Ridge)

camel - 1C, 1C(a)
deer - 1C
horse - 2C(a), 1PC(a)
carnivore - 1PC, 1C(a)
mustelid - 1C(a)

Protolabis sp.
Homocamelus sp.(a)
Michenia sp.(a)
Aepycamelus sp.(a)
Brachycrus sp.(a)

⊛ 115. N of Arroyo Seco, in SW¼ SE¼ sec. 16, T 20 N, R 9 E (Skull Ridge)

camel - 1C

⊛ 116. Arroyo Seco; Skull Ridge. Includes ⊛a) Left fork of Arroyo Seco (Skull Ridge)

camel - 4PC, 1C(a)
oreodont - 1PC
horse - 1C
Hypohippus - 1C, 1PC
rhino - 1PC
beaver - 1C

Mylagaulidae

⊛ 117. Arroyo Seco; W of highway (Pojoaque?)

camel - 1PC

⊛ 118. Between Arroyo Seco and White Operation Wash (N of Arroyo Seco Wash) (Skull Ridge)

camel - 3C, 5PC, 1 PSk
horse - 1C
rhino - 1C

"unnamed new camel taxon 2"
Aepycamelus sp.
Equinae

⊛ 119. Between White Operation and Intermediate Wash (which is between Arroyo Seco and White Operation Washes). Includes N part of Intermediate Wash (Skull Ridge)

camel - 3C, 2PC, 1 PSk
Protolabinae - 1C, 1PC

Miolabis sp.
"unnamed" new camel taxon 2"

⊛ 120. White Operation Wash (general) (Skull Ridge)

camel - 6C, 5PC, 2PSk
deer - 3C, 1PC
horse - 2C
rhino - 1C
carnivore - 1C, 2PC, coprolites
rodent - 1C
Desmythyus? - 1PC

Miolabis sp.
"unnamed new camel taxon 2"
Homocamelus sp.
Protolabinae
Meryceros crucianus
M. major
Cosoryx major
Teleoceras sp.
Leptocyon vafer
"Tomarctus" kelloggi

⊛ 121. White Operation Wash, N side (Skull Ridge)

camel - 1C, 3PC
deer - 1C
horse - 1C, 3PC
rhino - 1C

Aepycamelus sp.
Teleoceras sp.
Equinae

⊛ 122. N of White Operation Wash, Includes ⊛a) sec. 9, T 20 N, R 9 E
⊛b) SE¼ sec. 4, T 20 N, R 9 E (Skull Ridge)

camel - 1C, 4PC, 1C(b)
Protolabinae - 1PC
Aepycamelus sp- 1C, 1PC
deer - 2C
Meryceros - 1C, 1PC, 1H
horse - 1C, 2PC
Hypohippus - 1C
rhino - 1C, 1PC
carnivore - 1C
rodent - 1C, 1 PSk
turtle - 1 Sk

Miolabis sp.
"unnamed new camel taxon 1"
Protolabinae
Aepycamelus sp.
merycodont
Blastomeryx sp.
Meryceros crucensis
Teleoceras
Tomarctus sp.
T. confertus
Leptocyon vafer

⊛ 123. N of White Operation Wash, NE¼ sec. 9, T 20 N, R 9 E (Skull Ridge)

camel - 1 PSk
rhino - 1PC

Michenia sp.

⊛ 124. White Operation Quarry (in sec. , T 20 N, R 9 E) (Skull Ridge)
Includes ⊛a) 200 yards S of the Quarry)

camel - 7C, 1PC, 1PC(a)
deer - 1C, 1PC
merycodont - 1C(a), 1PC(a)
horse - 2C, 1PC
bird? - 1PC

Miolabis sp.
Homocamelus sp.
◆ *Rakomylus raki*
Bassariscus sp.

⊛125. White Operation Wash near Santa Cruz Divide, NW¼ sec. 4, T 20 N, R 9 E (Skull Ridge) ?

Hypohippus - 1C

⊛126. White Operation Wash, S side (Skull Ridge)

camel - 1C
deer - 1C, 2PC
horse - 2C, 3PC
rhino - 1PC
carnivore - 1PC
rodent - 1C
bird - 1PC

⊛127. S and SE of White Operation Wash (general) (Skull Ridge)

camel - 3C, 5PC
rhino - 2PC
Dicotherium - 1C
turtle - 1 PSk

Protolabinae
Protolabis sp.
"unnamed new camel taxon 2"
Aepycamelus sp.
Michenia sp.

merycodont
* Meryceros crucensis
M. crucianus?
Blastomeryx sp.
Pseudoparablastomeryx francescita
Brachycrus sp.
B. rusticus riograndensis
Ustatochoerus medius
novomexicanus
Equinae
Teleoceras sp.
Tomarctus sp.
Eucastor tortus
Bassariscus sp.

⊛128. White Operation Wash; tributary on S side. Includes ⊛a) "just E of Anvil fault" (Skull Ridge)

camel - 1 PSk, 1 PC(a)
horse - 3C(a), 2PC(a), 1D(a)

⊛129. W of White Operation Quarry (Skull Ridge)

camel - 1C

Equinae
Teleoceras sp.

⊛130. 1 mile E of White Operation Wash (Skull Ridge or Nambe)

"unnamed new camel taxon 2"

⊛ 131. In triangle between Highway 64, road to White Operation Wash, and the Santa Cruz River - SW¼ sec. 7, T 20 N, R 9 E (Pojoaque)

camel - 1C, 1PC
carnivore - coprolite

⊛ 132. S of Arroyo Seco (=Big) Wash (general) (Skull Ridge and Pojoaque)

camel - 3C, 6PC
oreodont - 1C
rhino - 1C
carnivore - 1C
rabbit - 1C

Miolabis sp.
Homocamelus sp.

Aepycamelus sp.
Alticamelus
Meryceros crucianus?
Teleoceras sp.
Tomarctus confertus
"T." kelloggi
Equinae

133. W side of Arroyo Seco Wash (Pojoaque?)

Teleoceras sp.
Canidae, new genus 2

⊛ 134. S of Arroyo Seco, SW¼ sec. 22, T 20 N, R 9 E (Skull Ridge)

camel - 1 PSk

⊛ 135. S of Arroyo Seco, NE¼ NW¼ sec. 28, T 20 N, R 9 E (Skull Ridge)

camel - 5C, 5PC, misc.
horse - 1C, 3PC
rhino - 2PC

⊛ 136. "Sisters Hills (= 3 Sisters Hills) (general) (Skull Ridge)

camel - 2C, 1PC

Protolabis sp.
Equinae
Teleoceras sp.

⊛ 137. N and a little W of Three Sisters, towards Santa Cruz (Skull Ridge?)

camel - 2C, 3PC
horse - 2PC
Hypohippus - 1C
rhino - 1PC

Miolabis sp.
Aepycamelus sp.
Equinae

⊛ 138. N of Three Sisters on Arroyo Seco Wash (Skull Ridge)

camel - 1C, 1PC

⊛ 139. W of Three Sisters Buttes (Skull Ridge or Pojoaque)

Protolabis sp.

⊛ 140. About 300 yards E of Three Sisters Buttes (Skull Ridge)

camel - 4C, 2PC
horse - 2PC
rodent - 1C

Teleoceras sp.

⊛ 141. 1 ½ miles E of Three Sisters Buttes (Skull Ridge)

Protolabis sp.
Equinae
Teleoceras sp.

⊛ 142. Just S of Three Sisters Hills (Skull Ridge)

"unnamed new camel taxon 2"

⊛ 143. SE of Three Sisters (general) (Skull Ridge)

Protolabis sp.
Aepycamelus sp.

⊛ 144. SE of Three Sisters, SE¼ sec. 17, T 20 N, R 9 E (Skull Ridge)

camel - 2C

Tomarctus confertus

⊛ 145. SE of Three Sisters, NW¼ NW¼ sec. 21, T 20 N, R 9 E (Skull Ridge)

camel - 2C

"unnamed new camel taxon 2"
Teleoceras sp.

⊛ 146. Joe Rak Wash, S Skull Ridge (general) (Skull Ridge)

camel - 7C, 7PC
deer - 1PC, 1H
Ramoceros - 2H
oreodont - 1C, 1PC
horse - 3PC, 1D
rhino - 1PC
carnivore - 1C, 1PC
rodent - 1D

Miolabis sp.
Protolabis sp.

Michenia sp.
Aepycamelus sp.
✱ *Rakomylus raki*
Brachycrus sp.
◆ *B. rusticus riograndensis*
Equinae
Teleoceras sp.
✱ *Hemicyon ursinus*
Tomarctus confertus
Mylagaulidae

⊛ 147. Joe Rak Wash, Skull Ridge; sec. 21, T 20 N, R 9 E. Includes
⊛ a) NW¼ sec. 21, (see also #145) (Skull Ridge)

camel - 1C(a), 3PC(a)
oreodont - 1C, 1PC
horse - 1C(a), 1PC(a)
carnivore - 1C
wood - (a)

⊛ 148. Joe Rak Wash, Skull Ridge; SW¼ sec. 29, T 20 N, R 9 E (Skull Ridge)

camel - 7C, 6PC, 1 PSk, misc.
Alticamelinae - 1PC
deer - 1H
horse - 1C
rhino - 2C, 1PC
carnivore - 1C, 2PC, misc
mustelid - 1PC
rodent - 1PC

⊛ 149. SE branch, Joe Rak Wash; NE¼ NE¼ sec. 29, T 20 N, R 9 E (Skull Ridge)

camel - 5C, 8 PC, misc.
Protolabinae - 1C, 1PC
oreodont - 1PC
horse - 1C, 2PC, 1 PSk
carnivore - 1C

Protolabinae
Protolabis sp.
Equinae

150. SE branch, Joe Rak Wash; SE¼ SE¼ sec. 29, T 20 N, R 9 E (Skull Ridge)

camel - 1C, 1PC

⊛ 151. Joe Rak Wash, Skull Ridge; NE¼ NE¼ sec. 20, T 20 N, R 9 E (Skull Ridge)

camel - 1C, 1PC
rhino - 1C

"unnamed new camel taxon 2"

⊛ 152. Joe Rak Wash, Skull Ridge; corner of sec. 20 & 29, T 20 N, R 9 E (Skull Ridge)

carnivore - 1C

⊛ 153. Middle Fork, Joe Rak Wash, Skull Ridge; on line between sec. 28 & 29, T 20 N, R 9 E (Skull Ridge)

camel - 3C, 1PC, 1 Sk
Cervidae - 1PC
lizard - 1C

Protolabis sp.
Equinae

154. E fork, Joe Rak Wash; includes several closely spaced localities:
⊛a) SW¼ sec. 16, T 20 N, R 9 E
⊛b) SE¼ SE¼ sec. 16, T 20 N, R 9 E (all Skull Ridge)
⊛c) SW¼ SW¼ sec. 16, T 20 N, R 9 E
⊛d) SE¼ SE¼ sec. 17, T 20 N, R 9 E
See also # 115 for another locality in sec. 16

camel - 2C, 1PC
deer - 1C, 1PC
carnivore - 1C

Homocamelus sp.
Teleoceras sp.
Bassariscus sp.

⊛155. E fork, Joe Rak Wash; Skull Ridge; sec. 22, T 20 M, R 9 E
(Skull Ridge)

camel - 5C, 5PC
deer - 1C
horse - 3C, 3PC
rhino - 1C, 4PC
carnivore - 1C, 1PC
rodent - 1C

Equinae

⊛156. Palm Branch, E fork of Joe Rak Wash (Skull Ridge)

camel - 1C, 1PC, 1 PSk

Homocamelus sp.
Aepycamelus sp.

157. Head of Joe Rak Wash (Skull Ridge)

camel - 1C, 1PC, misc.
horse - 1C
rhino - 2PC

Protolabis sp.
Homocamelus sp.
Aepycamelus sp.

158. S end of Joe Rak Wash (Skull Ridge)

camel - 1PC

159. SW fork, Joe Rak Wash (Skull Ridge)

Aepycamelus sp.

⊛160. South Skull Ridge (general; no wash mentioned) (Skull Ridge)

camel - 8C, 7PC, 3 PSk
oreodont - 1C
horse - 1PC
rhino - 1C, 2PC
carnivore - 1C
wood

Homocamelus sp.
"unnamed new camel taxon 2"
Protolabis sp.
Miolabis sp.
Michenia sp.
Merycoidodontidae
Merychyus (Metoreodon) sp.
Dicotylidae
Tomarctus confertus
Heteromyidae
Schizodontomys sp.

⊛ 161. "Skull Ridge" (general, no wash mentioned) (Skull Ridge)

camel - 2C, 1PC
Protolabinae - 1PC

Miolabis sp.
Homocamelus sp.
Protolabis sp.
Michenia sp.

Aepycamelus sp.
*Rakomylus raki
*Meryceros crucensis
M. crucianus
Cosoryx ilfonsensis
Rakomeryx sp.
Blastomeryx sp.
merycodont
Ramoceros (Subramoceros) sp.
Meryceros (Submeryceros) minor
Brachycrus rusticus riograndensis
B. sp.
Merycochoerinae
Dicotylidae
Ramoceros ramosus
Equinae
Aphelops sp.
Teleoceras sp.
Pseudaelurus sp.
Tomarctus confertus
T. sp.
Canidae, new genus
Amphicyon ingens
Leptocyon vafer
Hemicyon sp.
Miomustela sp.
Mesogaulus sp.
Eucastor tortus

162. South Skull Ridge, SE¼ NE¼ sec. 32, T 20 N, R 9 E (Skull Ridge)

camel - 1C
rhino - 1C

163. South Skull Ridge, several localities in sec. 33, T 20 N, R 9 E:
a) NW¼ SW¼, b) SW¼ NW¼, c) NE¼ NE¼ (Skull Ridge)

camel - 1C, 2PC
horse - 1PC
rhino - 2PC
wood

⊛ 164. East Skull Ridge (Skull Ridge)

Brachycrus rusticus riograndensis
Hesperhys sp.
Equinae
Protolabinae
Aepycamelus spp.

⊛165. SE corner of Skull Ridge, sec. 27 (?), T 20 N, R 9 E (Skull Ridge)

Michenia sp.
Protolabis sp.
Homocamelus sp.
Aepycamelus sp.

166. West Slope, Skull Ridge (Skull Ridge)

Aepycamelinae, new? taxon
Michenia sp.

⊛167. Jack Wilson Wash. Includes ⊛a) head of Jack Wilson Wash, ⊛b) S of Arroyo Seco just E of mouth of Jack Wilson Wash (Skull Ridge)

camel - 1PC
oreodont - 1PC, 1D, 1C(b)
horse - 1PC
Hypohippus - 1PC(a)
wood -

⊛168. Jack Wilson Wash, W fork, passes NW corner, sec. 27, T 20 N, R 9 E (Skull Ridge and Nambe?)

camel - 1C, 2PC
horse - 1C, 2PC
rhino - 1C
carnivore - 1PC

Miolabis sp.
Aphelops

⊛169. Jack Wilson Wash, E fork, NW¼ sec. 27, T 20 N, R 9 E (Skull Ridge)

camel - 4C, 2PC
rhino - 1C
carnivore - 1C, 1PC

Miolabis sp.
"unnamed new camel taxon 1"

170. Nambe Pueblo (nonspecific) (Nambe)

Miolabis sp.

171. NE of Nambe Pueblo, Nambe Pueblo Grant (Nambe)

carnivore - 1C

172. Divide between Arroyo Seco and Nambe Creek (Skull Ridge or Nambe)

camel - 1PC

173. W side of hill between Joe Rak Wash-Arroyo Seco Wash system, and Nambe Creek system, 1½ miles S of N boundary of Pojoaque Grant and ½ mile W of road (Skull Ridge?)

camel - 1C, 1 PSk

174. Between Joe Rak Wash and Nambe Creek, W of highway. Includes a) E of highway, b) Nambe side of divide (Skull Ridge)

camel - 4C, 1 PSk(a), 1C(b)
2PC(b)
Protolabinae - 1C
horse - 1C(b)
rhino - 1C
carnivore - 1PC(b)
Mustelidae - 1C

Protolabinae
Tomarctus confertus (b)

175. Head of Nambe Creek (Nambe)

Aepycamelus sp.

176. Nambe, N side of fault block, S of Santa Cruz drainage (Nambe?)

Tomarctus sp.

177. Nambe Grant, $\frac{1}{4}$ mile W of N Cundiyo Road near N boundary (Nambe?)

camel - 1PC
rodent - 1D

Aepycamelus sp.

178. Nambe Creek, W of Nambe Pueblo Grant boundary, Pojoaque Grant (Skull Ridge)

camel - 2C, 2PC
deer - 1H

?⊛ 179. Chimayo-Nambe Road (Nambe)

"unnamed new camel taxon 2"

⊛ 180. "Chimayo" (Nambe)

Prohyaena sp.

⊛ 181. "Near Chimayo", 1 mile S of mouth of Rio Quemado (Nambe)

rhino - 1C

Aphelops sp.
Peraceras (small species)

⊛ 182. Chimayo; from wash entering Santa Cruz $\frac{1}{4}$ mile above Sanctuario Mission (Nambe)

camel - 2C
merycodont - 1C, 1H
carnivore - 3PC

⊛ 183. $1\frac{1}{2}$ miles N of Chimayo (Skull Ridge or Nambe)

Pseudaelurus marshi?

⊛ 184. 2 miles NW of Chimayo (Skull Ridge?)

Michenia

⊛ 185. West of Chimayo (Skull Ridge or Nambe)

Merychyus (*Metoreodon*) sp.

⊛ 186. ¼ mile W of Santa Cruz Dam (Nambe)

Protolabis heterodontus

187. Hernandez locality; 100 paces a little S of W of corner stake in wash of sec. 18 & 19, T 21 N, R 8 E (Chamita)

(no record)

188. ½ mile W of new Hernandez Schoolhouse, sec. 19, T 21 N, R 8 E (Chamita)

camel - 1PC
deer - 1PC
carnivore - 1PC
rodent - misc.
sciurid? - misc.
beaver - 1PC
rabbit - misc.

Eucastor tortus

189. CHAMITA STRATOTYPE (= "San Juan Member" type locality); NW¼ sec. 10, and W½ sec. 3, T 21 N, R 8 E. These lists include fauna reported from the San Juan and Rak Camel Quarries. Fauna reported in MacFadden (1977, p. 785)

camel - 9C, 6PC
deer - 1C, 4PC
antelope - 8C, 2PC, 1D
horse - 30C, 9PC, 3D
carnivore - 2C, 4PC
rodent - 12C, 3PC
beaver - 4C
rabbit - 2C, 1PC
sloth - 1C
bird - 1PC

Megatylopus matthewi
Hemiauchenia vera
H. sp.
?*Plioceros* sp.
Osbornoceros osborni
Illingoceros alexandrae
Astrohippus ansae
Dinohippus interpolatus
Canis davisi
Aelurodon cf. *A. haydeni*
Bassariscus sp.
Plesiogulo sp.
Pliotaxidea garberi
?Longirostrine gomphotheriidae
?*Mylagaulus* sp.
"*Dipoides*" *williamsi*
Hypolagus vetus
?*Pliometanastes galushai*

191. San Juan area, *Osbornoceras* horizon (Chamita)

camel - 1PC
antelope - 1C, 1PC

Plioceras blicki?
Osbornoceras osborni

192. Prospect A; same horizon as San Juan Quarry (Chamita)

antelope - 1PC, 4D
carnivore - 1C
mustelid - 1C

193. 1 mile above San Juan Bridge (Chamita)

Prohyaena sp.

194. 2 miles N of San Juan (Chamita)

Teleoceras sp.

195. Alcalde; beds N of Rio Grande along base of Black Mesa (Chamita)

Procamelus sp.
Osbornoceros osborni
Equinae
Teleoceras sp.
Vulpes stenognathus

196. Badger Wash, 5 miles N of Espanola, S of Canoe Mesa (Chamita)

Sthenictis sp.

197. Left off road from ruins of Yuque Yunque to village of Guique (Chamita)

camel - 1C, 1PC
carnivore - 1PC

198. East of Black Mesa (Chamita)

Meryceros crucensis
Ustatachoerus profectus espanolensis

199. Lyden Quarry (=Osbornoceros Quarry); 150' W of corner of sec. 16,17,20, & 21, T 22 N, R 9 E (Chamita)

camel - 1C, 1PC
deer - 2C
antelope - 2C
Osbornoceros? - 1C, 2PC
horse - 1D
carnivore - 1C
rodent - 2C, 1PC
mylagaulid? - 1PC
rabbit - 1PC

Megatylopus sp.
Plioceros blicki
Osbornoceros osborni
Canis sp.
Vulpes stenognathus
Osteoborus sp.

200. 1 mile N of Lyden Quarry (Chamita)

antelope - 1C
mustelid - 1C

201. ½ mile W of Lyden Quarry (Chamita)

carnivore - 1C

202 Rio del Oso-Abiquiu locality, N side of Deer Spring Branch, South Fork of Three Sand Hills Wash (Chama-el Rito/Ojo Caliente)

camel - 2PC
horse - 2C, 2 PSk

"unnamed new camel taxon 2"
Procamelus sp.
Aepycamelus sp.
Protolabis sp.
Michenia sp.
Meryceros crucensis
Longirostromeryx blicki
Merycoidodontidae
◆ _Brachycrus vaughani rioosoensis_
Equinae
Eucastor cf _E planus_

203. Central Rio del Oso, W side (Chama-El Rito/Ojo Caliente)

camel - 1PC

204. Second tributary on N side of Rio del Oso (Chama-El Rito/Ojo Caliente)

camel - 1C
carnivore - 1C

205. Second tributary N of mouth of Rio del Oso (Chama-El Rito/Ojo Caliente)

camel - 1C, 1D
deer - 2H
rhino - 1C
mastodon - 2C, 5PC

206. South Wash, at diatomite mine (Chama-El Rito/Ojo Caliente)

rodent - 1C, 1PC, 1D

207. Dike Wash (general) (Chama-El Rito/Ojo Caliente)

camel - 1PC
deer - 1H
Longirostromeryx - 1C
oreodont - 1PC
horse - 1PC
mastodon - 1C
carnivore - 1C
Aelurodon - 1C, 1PC

Protolabis sp.

208. Dike Wash; tributary on N side, ¼ mile below Hole-in-Rock fork (Chama-El Rito/Ojo Caliente)

camel - 1C, 1 PSk

209. Dike Wash, Ash fork (Chama-El Rito/Ojo Caliente)

camel - 1PC
deer - 1C

210. Dike Wash, Skeleton fork (Chama-El Rito/Ojo Caliente)

Protolabinae - 1 PSk
merycodont - 1H

Protolabis sp.

211. Shorty Moore Wash (general). Includes a) Near head, and b) N side (Chama-El Rito/Ojo Caliente)

camel - 1C(a), 1PC(a)
Protolabinae - 2C(a)
deer - 1PC
merycodont - 2H(a)
horse - 1PC
carnivore - 1C, 3PC(b)

Protolabis sp.
Equinae

212. Shorty Moore Wash, South fork (Chama-El Rito/Ojo Caliente)

mastodon - 1C

213. Sand Cliffs Wash, N side (Chama-El Rito/Ojo Caliente)

camel - 2PC

Procamelus sp.

214. Sand Cliffs Wash, S side (Chama-El Rito/Ojo Caliente)

turtle - 1 Sk
microfauna - misc.

215. Three Sandhills Wash, near head (Chama-El Rito/Ojo Caliente)

camel - 1C, 1PC
Procamelus - 1C
deer - 2H
mastodon - 1C, 1PC
turtle - 1PC, shell

Equinae

216. Three Sandhills Wash; next ridge to S (Chama-El Rito/Ojo Caliente)

Prohyaena - 1C

Prohyaena sp.

217. South fork, Three Sandhills Wash (including N and S sides) (Chama-El Rito/Ojo Caliente) See also # 202. List for this locality probably includes some remains found at locality #202.

camel - 13C, 11PC, 4 PSk
deer - 1PC, 3H
oreodont - 2c, 1PC
horse - 2C, 1PC, 1D
Hypohippus - 1C, 1D
carnivore - 4C, 2PC
Prohyaena - 1C
rabbit - 1C, 1PC

Protolabinae
Protolabis sp.
Ustatochoerus sp.
Equinae
Pseudaelurus marshi?
Tomarctus confertus
Prohyaena sp.

218. Near Three Sandhills Wash. Includes a) Left fork S of Three Sandhills, b) 2nd fork, on N side, c) 1 mile W of road, d) Above Lumber Springs, e) Lobato branch of South fork, Three Sandhills Wash . (Chama-El Rito/Ojo Caliente)

camel - 3C, 2PC, 1 PSk
deer - 1D
oreodont - 1C, 1PC, 1PSk
horse - 1PC
carnivore - 1C, 1PC
beaver - 1C

"unnamed new camel taxon 2"
Ustatochoerus sp.
Tomarctus sp.

219. 2 miles W of Three Sandhills, in right fork of wash just S of Three Sandhills (Chama-El Rito/Ojo Caliente)

mastodon - 1 PSk

220. Conical Hill Quarry, N side of Conical Hill Wash, a tributary of the S fork of Three Sandhills Wash system (Chama-El Rito/Ojo Caliente)

camel - 20C, 16PC, 1D, 1 PSk
Alticamelinae - 2C
deer - 17C, 14PC, 1D, 1H, 2 PSk
Cervidae - 1PC, 1D
antelope - 2C, 1PC
oreodont - 2PC
horse - 27C, 40PC, 1D
Pliohippus - 1C
Hypohippus - 1C
rhino - 3C, 1PC, 1D
mastodon - 1C, 3PC, 2D
carnivore - 10C, 11PC
mustelid - 1PC
?Hemicyon - 1PC
Metechinus - 1C
rodent - 17C, 1PC, 1D
mylagaulid - 9C
rabbit - 1C, 1D

Protolabinae
"unnamed new camel taxon 2"
Procamelus sp.
Aepycamelus sp.
Cranioceros teres
Ustatochoerus sp.
Equinae
Aphelops sp.
Leptocyon vafer
Tomarctus sp.
Prohyaena sp.
Carpocyon sp.
Mylagaulidae
Eucastor cf E. planus

221. Divide between Conical Hill Wash and Aelurodon Wash (Chama-El Rito/Ojo Caliente)

deer - 2PC, 1H
horse - 1PC
mastodon - 1D
carnivore - 2PC

222. Aelurodon Prospect, on first tributary S of Conical Hill Wash (Chama-El Rito/Ojo Caliente)

camel - 1C, 4PC
deer - 11C, 15H, 1D
antelope - 1D, 1H
oreodont - 1PC
horse - 4C, 12PC, 4D
Hypohippus - 2D
mastodon - 4D
rhino - 2D
carnivore - 7C, 2PC, 1D
Prohyaena - 1C
mammalia - 8C, 1D
rodent - 2C, 1D

Protolabinae
Ustatochoerus sp.
Equinae
Prohyaena sp.
Tomarctus sp.
Mylagaulidae

223. Long Walk Wash (first wash S of Aelurodon Wash) (Chama-El Rito/Ojo Caliente)

carnivore - 1C
beaver - 1C

Eucastor tortus

224. Camel fork of Three Sandhills Wash (= N fork of Three Sandhills Wash). Includes a) South side of Camel fork (Chama-El Rito/Ojo Caliente)

camel - 2C
Protolabinae - 1 PSk
Procamelus - 1C(a), 1PC(a)
oreodont - 1C(a), 1PC(a)
mastodon - 1C
turtle - 1PC, shell

Procamelus sp.
Protolabis sp.
Ustatochoerus sp. (a)

225. First Wash S of Camel fork (Chama-El Rito/Ojo Caliente)

horse - 1PC

226. Junction Wash, crosses highway 84 a few yards E of junction with State Road 96 to El Rito (Chama-El Rito/Ojo Caliente)

camel - 1C, 4PC
Protolabinae - 1PC

Aepycamelus sp.
"unnamed new camel taxon 1"

227. 3 miles S of junction of El Rito Road with highway 84 (Chama-El Rito/Ojo Caliente)

camel - 1 PSk

228. 2 miles S of Indian Ruins, which are 2½ miles SE of Abiquiu (Chama-El Rito/Ojo Caliente)

camel - 2C, 1PC
deer - 2H
rodent - 1C

229. 2 miles S of Indian Ruins, in wash passing immediately W of ruins (Chama-El Rito/Ojo Caliente)

horse - 1 PSk

230. 2 miles SW of Indian ruins (Chama-El Rito/Ojo Caliente)

camel - 1C, 1PC, 1 PSk

231. First right hand branch of large wash W of Indian ruins (Chama-El Rito/Ojo Caliente)

camel - 2C
Brachycrus - 1C

232. S and W of Dikes (Chama-El Rito/Ojo Caliente)

camel - 7C, 8PC
deer - 1C
merycodont - 1H, 1PSk
Cervidae - 1C
oreodont - 1PC
horse - 1C, 1PC
mastodon - 4C, 4PC
carnivore - 1C
rabbit - 1C

Ustatochoerus sp.

233. Kunye Ruins (=Turquoise Ruins) Wash, W of Springline fault (Chama-El Rito/Ojo Caliente)

camel - 1C
deer - 1C
oreodont - 1C

Promylagaulus novellus

234. South fork, Kunye Ruins Wash (Chama-El Rito/Ojo Caliente)

camel - 3C, 1PC
horse - 1 PSk

Michenia sp.
Protolabis sp.

235. Middle fork, Kunye Ruins Wash (Chama-El Rito/Ojo Caliente)

camel - 4C, 3PC, 2 PSk
deer - 1C, 1PC
merycodont - misc.
rodent - 1C
mylagaulid - 1C

Michenia sp.
Protolabis sp.
Aepycamelus sp.

236. Chama- El Rito collecting locality (= type locality for Chama-el rito Member, see Galusha & Blick, 1971, p. 64 for precise localtion) (Chama-El Rito). List also includes fossils whose locality is just "Chama-El Rito"

camel - 5C, 3PC
Protolabinae - 1C
deer - 1C, 1PC
oreodont - 1C, 1PC
carnivore - 1PC, coprolite
Heteromyid rodent - 1C

Michenia sp.
Protolabinae
Protolabis sp.
Aepycamelus sp.
Ramoceros ramosus
R. (Subramosus) sp.
merycodont
Blastomeryx francesca
Meryceros crucensis
Longirostromeryx sp.
Ustatochoerus medius novomexicanus
U. sp
Merycoidodontidae
Equinae
Peraceras (small species)
Prohyaena sp.
Heteromyidae

237. "South Chama-El Rito" (Chama-El Rito/Ojo Caliente)

Procamelus sp.

238. "North Chama-El Rito" (Chama-El Rito/Ojo Caliente)

Aepycamelus sp.

?⊛239. Chama-El Rito; wash leading from crest to El Rito Creek (Chama-El Rito/Ojo Caliente)

deer - 2PC
Meryceros - 1PC, 2H
Ramoceros - 1H
horse - 1PC

240. Chama-El Rito; South fork of large wash draining Llano Lobato on El Rito side of crest (Chama-El Rito/Ojo Caliente)

camel - 1PC

⊛241. Arroyo las Lagunitas, a tributary of El Rito Creek, center of sec. 14, T 23 N, R 7 E (Chama-El Rito/Ojo Caliente)

turtle - 1PC

242. Chama-El Rito; W rincon of Canada de Tio Alfonso (Chama-El Rito/ Ojo Caliente)

oreodont - 1 PSk Equinae
horse - 1PC

243. Middle rincon of Canada de Tio Alfonso, Jose de Lobato Grant (Chama-El Rito/Ojo Caliente)

deer - 1C
carnivore - 2C, 1PC

244. East rincon of Canada de Tio Alfonso (Chama-El Rito/Ojo Caliente)

camel - 2PC
oreodont - 1PC
carnivore - 1C
rodent - 1PC

245. First tributary N of Rio Lobato (and Lobato Ranch) (Chama-El Rito/Ojo Caliente)

Protolabis sp.

246. El Rito Creek. (Abiquiu Tuff)

camel - misc.
carnivore - 1PC

247. El Rito Creek, 1 mile SE of Plaza Media ruins (Chama-El Rito/ Ojo Caliente)

camel - 1 PSk

248. Cerro de las Minas Creek, NW of El Rito Creek (Chama-El Rito/ Ojo Caliente)

camel - 1C, 1PC
turtle - 1PC

⊛ 249. Ojo Caliente (nonspecific) (Chama-El Rito/Ojo Caliente)

Procamelus sp.
"unnamed new camel taxon 2"
Aepycamelus sp.
✱ *Meryceros crucensis*
merycodont
Cosoryx serroensis
Ramoceros ramosus
Ustatochoerus skinneri santacruzensis
U. *medius novomexicanus*
U. sp.
Equinae
◆ *Ocalientinus ocaliensis*
✱ *Serridentinus productus*
Leptocyon vafer
Prohyaena sp.
Hemicyon sp.
Sthenictis sp.
Eucastor tortus
Eucastor cf E. *planus*

250. Along Black Mesa facing Ojo Caliente (= W side of Black Mesa) (Chama-El Rito/Ojo Caliente)

deer - 1C
horse - 1D
rhino - 1C
peccary - 1C
mastodon - 1D
Pliometanastes - 1D

"peccary"
Pliometanastes sp.
Teleoceras sp.
Aelurodon sp.

⊛ 251. Middle Ojo Caliente Locality, Ojo Caliente Wash. Includes ⊛ a) North fork, and ⊛ b) South fork (Chama-El Rito/Ojo Caliente)

camel - 8C, 4PC, 1D, 2C(a), 2C(b)
deer - 7C, 5PC, 12H, 1H(a), 3C(b), 3H(b)
Ramoceros - 1H(b)
oreodont - 3C, 1PC
horse - 1C, 1PC, 1D
rhino - 1C(b)
mastodon - 2C, 7PC, 2C(a), 1C(b) 1D(b)
carnivore - 2C, 1PC, 1D, 1C(b)
Prohyaena - 1C
rodent - 2C(b)
rabbit - 1C

Ramoceros ramosus
Ustatochoerus sp.(a)
Equinae
Aphelops sp.
Leptocyon vafer
Tomarctus sp.
Prohyaena sp.

⊛ 252. Middle Ojo Caliente; N side of Prince Ranch Wash (= Ojo Prospect) (Chama-El Rito/Ojo Caliente)

camel - 10C, 7PC, 1D
deer - 24C, 5PC, 20H, 1D
Ramoceros - 3H
horse - 1C, 2PC, 1D
Hypohippus - 1C
rhino - 1C
mastodon - 1C, 3PC
carnivore - 1C
Prohyaena - 1D
rodent - 13C, 2PC, misc.

Equinae
"*Mustela*"
Eucastor tortus

⊛ 253. Middle Ojo Caliente; S side of Prince Ranch Wash (Chama-El Rito/Ojo Caliente)

camel - 1C, 2PC
Protolabinae - 1C
Ramoceros - 1H
beaver - 1C

Protolabis sp.

⊛ 254. Middle Ojo Caliente; head of S fork of Prince Ranch Wash (Chama-El Rito/Ojo Caliente)

carnivore - 1C

⊛ 255. South (=Lower) Ojo Caliente (Chama-El Rito/Ojo Caliente)

Meryceros crucensis
Protolabis sp.

⊛ 256. Lower Ojo Caliente; N fork of Crypt Wash (Chama-El Rito/Ojo Caliente)

camel - 1PC
deer - 2H
Ramoceros - 1H
horse - 1PC
mastodon - 1C, 1PC
carnivore - 2PC
Amphicyon? - 1PC
horse - 1PC
wood

⊛ 257. Lower Ojo Caliente; middle branch of Yazoo Wash (Chama-El Rito/Ojo Caliente)

camel - 1C
horse - 3C, 1PC

Equinae

⊛258. Lower Ojo Caliente; Yazoo Wash system (Chama-El Rito/Ojo Caliente)

camel - 1PC
merycodont - 1C, 1PC, 1H
horse - 1PC
carnivore - 1PC
rodent - 1PC

Prohyaena sp.
Aelurodon? *haydeni*

⊛259. South branch, Yazoo Wash (Chama-El Rito/Ojo Caliente)

deer - 2C
Ramoceros - 2H
oreodont - 1C

⊛260. North branch, Yazoo Wash (Chama-El Rito/Ojo Caliente)

beaver - 1C

?*Eucastor* sp.

⊛261. Hidden Wash system (tributary of Yazoo Wash) (Chama-El Rito/Ojo Caliente)

camel - 1PC
horse - 1PC

⊛262. South branch, Hidden Wash, which enters Yazoo Wash $\frac{1}{2}$ mile above its mouth (Chama-El Rito/Ojo Caliente)

camel - 1C
Ramoceros - 2H
mastodon - 1PC

⊛263. North branch, White Ledge Wash (Chama-El Rito/Ojo Caliente)

camel - 1PC

⊛264. Middle branch, White Ledge Wash (Chama-El Rito/Ojo Caliente)

mastodon - 1PC

⊛265. Upper (=North) Ojo Caliente (Chama-El Rito/Ojo Caliente)

Michenia sp.
Protolabis sp.
Aepycamelus sp.
merycodont
Ramoceros *ramosus*

⊛266. Upper Ojo Caliente, in Adobe Walls Wash, 4 miles above mouth Includes also ⊛a) 3 miles above mouth, ⊛b) 4$\frac{1}{2}$ miles above mouth, ⊛c) $\frac{1}{4}$ mile above mouth (Chama-El Rito/Ojo Caliente)

Protolabinae - 1C, 1PC
deer - 1C(b),
carnivore - 1PC, 1C(c), 1C(a)

Protolabis sp.

⊛267. Upper Ojo Caliente; Adobe Walls Wash (general) (Chama-El Rito/Ojo Caliente)

camel - 2C, 3PC
deer - 1PC
oreodont - 3C, 3PC
horse - 1PC
rhino - 1C
Dipodomys - misc
rabbit - 1C, 1PC
turtle - 1PC

Ustatochoerus sp.

⊛268. Adobe Walls Wash; tributary on S side of wash, 2 miles from mouth (Chama-El Rito/Ojo Caliente)

camel - 1PSk
mastodon - 1C

⊛269. Adobe Walls Wash; tributary on S side of wash, 1½ miles from mouth (Chama-El Rito/Ojo Caliente)

camel - 1C
mastodon - 2C, 1PC

⊛270. Adobe Walls Wash; tributary on N side of wash, 1½ miles from mouth (Chama-El Rito/Ojo Caliente)

camel - 2PC

⊛271. First large sandy wash S of Adobe Walls Wash (= Old Mastodon Wash?) (Chama-El Rito/Ojo Caliente)

deer - 1C, 1H
oreodont - 1C, 1PC
mastodon - 1C
carnivore- 1PC

Ustatochoerus sp.

⊛272. Upper Ojo Caliente; first steep walled wash S of intrusive (Chama-El Rito/Ojo Caliente)

camel - 2PC
oreodont - 1C, 1PC
horse - 1PC
rabbit - 1C

"unnamed new camel taxon 2"

⊛273. Upper Ojo Caliente; ½ mile above second steep walled wash S of intrusive (Chama-El Rito/Ojo Caliente)

camel - 3C, 1PC
deer - 1C, 1 PSk
turtle - misc.

⊛ 274. North Ojo Caliente, SW¼ sec. 8, T 24 N, R 8 E (Chama-El Rito/Ojo Caliente)

camel - 1C, 1PC

⊛ 275. NE¼ sec. 8, T 24 N, R 8 E (Chama-El Rito/Ojo Caliente)

camel - 1PC

⊛ 276. North Ojo Caliente, SW¼ sec. 5, T 24 N, R 8 E (Chama-El Rito/Ojo Caliente)

camel - 1C, 1PC

⊛ 277. 3 miles N of Ojo Caliente (Chama-El Rito/Ojo Caliente)

oreodont - 1C, 1PC

Ustatochoerus medius novomexicanus
U. sp

⊛ 278. NE Ojo Caliente. Includes a) 3 miles NE of Ojo Caliente (Chama-El Rito/Ojo Caliente)

Protolabis sp.
Michenia sp. (a)
Ustatochoerus medius novomexicanus

⊛ 279. "NW Ojo Caliente" (Chama-El Rito/Ojo Caliente)

Procamelus sp.
Michenia sp.
Protolabis sp.
Ustatochoerus medius novomexicanus

⊛ 280. E of Ojo Caliente, including 2 miles E (Chama-El Rito/Ojo Caliente)

camel - 1C, 3PC
Protolabinae - 1C, 1PC
deer - 1PC, 1H
mastodon - 1C
horse - 1D
rhino - 1D

Aepycamelus sp.
Protolabis sp.

⊛ 281. "SE of Ojo Caliente" (Chama-El Rito/Ojo Caliente)

Michenia sp.

⊛ 282. W of Ojo Caliente (Chama-El Rito/Ojo Caliente)

merycodont - 1C, 1PC, 6H
beaver - 1C

Meryceros crucensis

?⊛283. Ojo Caliente Mountain, E of large fault (Chama-El Rito/Ojo Caliente)

Mylagaulidae

⊛284. Rinconada, NW¼ sec. 22, T 23 N, R 10 E (Chama-El Rito/Ojo Caliente)

camel - 1C, 1PC

⊛285. 1 mile W of Dixon (Chama-El Rito/Ojo Caliente)

Prohyaena sp.

286. Taos Road (?)

Plioceros blicki?

287. W of road near Sombrillo (?)

Meryceros crucensis

288. Just above site of Hungtec Indian ruins (?)

oreodont - 1 PSk   *Ustatochoerus* sp.

⊛ 289. "Santa Fe" (Tesuque)

Procamelus sp.
Protolabinae
Rakomylus raki
◆ *Ramoceros ramosus*
R. r. quadratus
◆ *R. (Paramoceros) palmulatus*
merycodont
"Paracosoryx" minimus
◆ *Ramoceras (Paramoceros) marthae*
Plioceros blicki
Meryceros crucensis
Cosoryx ilfonsensis
◆ *Blastomeryx francesca*
Cervoidea
✱?*Longirostromeryx blicki*
◆ *Cranioceros teres*
Equinae
Teleoceras sp.
Amphicyonidae
Amphicyon sp.
Canidae, new genus
Leptocyon vafer
Aelurodon sp.
Carpocyon sp.
Tomarctus (Depthodon) sp.
Hemicyon ursinus
H. sp.
Plionictis sp.
"Mustela" sp.
Promylagaulus novellus

⊛ 290. "Espanola" (Tesuque)

Protolabis sp.
"unnamed new camel taxon 2"
Megatylopus sp.
Miolabis sp.
Michenia sp.
merycodont
Ramoceros ramosus
R. sp.
Teleoceras sp.
Aphelops sp.
Leptocyon vafer
Cyonarctoides sp.
Pseudaelurus intrepidus?
Mylagaulus sp.
Merychyus (Metoreodon) sp.

291. "First District" (Pojoaque and Skull Ridge)

Ustatochoerus skinneri santacruzensis
Teleoceras sp.
Peraceras (small species)
Leptocyon vafer
Eucastor tortus

292. "Second District" (Pojoaque)

Teleoceras sp.
Peraceras (small species)
Prohyaena sp.
Scalopus sp.
Eucastor tortus

⊛ 293. "Third District" (Skull Ridge?)

Homocamelus sp.
Protolabis sp.
Ramoceros ramosus quadratus
Equinae
Teleoceras sp.
Leptocyon vafer
Tomarctus sp.
T. confertus
"*T.*" *kelloggi*

294. Between old and new Santa Fe roads (Tesuque)

Aepycamelus sp.
merycodont
Meryceros crucensis
Ramoceros ramosus
Teleoceras sp.
Pseudaelurus marshi

TABLE 4. Boxes of Santa Fe Group fossils from the Espanola Basin that remain unopened and uncatalogued (1939-1950)

Camels	2 boxes
Mastodons	29 3/4
Oreodonts	2
Rhinos	1
Turtles	6 1/4

TABLE 5. Stratigraphic range of fossil taxa identified from the Santa Fe Group. Many taxa are not yet formally defined, described or named; a complete list would include many more species than are presented here. Taxa listed for the Chamita include both Clarendonian and Hemphillian forms. Species described on the basis of type specimens from the Santa Fe Group are indicated with an asterisk. Abbreviations for lithostratigraphic units: T-U = Tesuque, undifferentiated; N = Nambe Mbr.; SR = Skull Ridge Mbr.; P = Pojoaque Mbr.; CR/OC = Chama-el Rito and Ojo Caliente Mbrs.; CH = Chamita Fm.

	T-U	N	SR	P	CR/ OC	CH	Other
ARTIODACTYLA							
Camels							
Protolabinae	x	x	x	x	x	x	
Protolabis spp.	x	x	x	x	x	x	Abiquiu tuff
Miolabis sp.		x	x	x			
Michenia sp.		x	x	x	x	x	
**Pliauchenia humphresiana* Cope			?				
Homocamelus sp.		x	x	x			
Procamelus sp.				x	x	x	
*?*P. vulcanorum* Cope				?			
Megatylopus matthewi						x	
Hemiauchenia vera						x	
Aepycamelus spp.		x	x	x	x	x	
**Rakomylus raki* Frick			x				
"unnamed new camel taxon 1"			x	x	x		
"unnamed new camel taxon 2"		x	x	x	x		

	T-U	N	SR	P	CER/ OC	CH	Other
Antilocapridae							
"merycodont"	x	x	x	x	x	x	
*_Meryceros_ _major_ Frick			x	x	x	x	
*_M._ _crucensis_ Frick				x	x	x	
*_M._ (_Submeryceros_) _crucianus_ Frick				x			
_M._ ?(_S._) _minor_			x	x			
_M._ ?(_S._) _minimus_	x						
*_Cosoryx_ _ilfonsensis_ Frick			?	x		?	
*_C._ (_Subcosoryx_) _cerroensis_ Frick						x	
*_Ramoceros_ _ramosus_ Frick				x	x		
*_R._ _r._ _quadratus_ Frick				x			
*_R._ (_Paramoceros_) _marthae_ Frick				x		x	
*_R._ (_P._) _palmatus_ Frick				x			
?_R._, new taxon			x		x		
*_Osbornoceros_ _osborni_ Frick						x	
*_Plioceros_ _blicki_ Frick				x			
Illingoceros _alexandrae_						x	
Gelocidae							
*_Pseudoceros_ _klausi_ Frick						x	
Moschidae							
*_Longirostromeryx_ _novomexicanus_ Frick				x			
_L._ sp.			x	x	x	?	
*_L._(?) _blicki_ Frick				x	?	?	
*_Blastomeryx_ _francesca_ Frick				x	?		
_B._ sp.		x	x				
Leptomerycidae							
*_Pseudoparablastomeryx_ _francescita_ (Frick)				x			

	T-U	N	SR	P	CER/ OC	CH	Other
Cervidae							
*_Craniocerus teres_ Frick				x	x		
Oreodonts							
Merycochoerinae			x				
*_Brachycrus rusticus riograndensis_ Schultz & Falkenbach		x					
*_B. vaughni rioosoensis_ Schultz & Falkenbach			x				
_B._ sp.			x				
Merychus (_Metoreodon_) sp.			x				
*_Ustatochoerus medius novomexicanus_ (Frick)				x	x		
*_U. californicus raki_ S. & F.				x			
*_U. profectus espanolensis_ S. & F.				x		x	
*_U. skinneri santacruzensis_ S. & F.				x	x	?	
_U._ sp.				x	x		
Dicotylidae							
Hesperhys sp.			x				
Prosthennops sp.						x	
PERISSODACTYLA							
Horses							
Equinae	x	x	x	x	x	x	
*_Merychippus calamarius_ (Cope)			x	x			
*_Hipparion sanfondensis_ Frick						x	
Astrohippus ansae						x	
Dinohippus interpolatus						x	

	T-U	N	SR	P	CER/ OC	CH	Other
Rhinoceroses							
Aphelops sp.		?	x	x	x		
**A. jemezanus* Cope				x		?	
*Cf. *A. meridianus*			?	?			
Peraceras crassus				x			
P. (small species)		?	x	x	x		
Teleoceras sp.		?	x	x	x	x	
PROBOSCIDEA							
Rhynchotherium sp.						x	
**Serridentinus productus* (Cope)				x	x	x	

NOTE: 6 other species described by Frick, *Ocalientinus ocaliensis*, *Megabelodon cruziensis*, *M. joraki*, *Trilophodon pojoaquensis*, *T.* (*Tatabelodon*) *riograndensis*, and *Trobelodon taoensis* are now considered to be junior synonyms of *S. productus*.

	T-U	N	SR	P	CER/ OC	CH	Other
CARNIVORA							
Amphicyonidae	x		x	x			
Amphicyon sp.	x			x			
A. ingens			x				
A. sinapius			x	x			
Canidae							
Canidae, new genus 1			x				
Canidae, new genus 2	x		x				
Canis davisi						x	
Vulpes stenognathus						x	
Leptocyon vafer	x			x	x	x	
L. sp.	x		x				
Prohyaena sp.	x			x	x	x	

	T-U	N	SR	P	CER/ OC	CH	Other
*P. wheelerianus (Cope)			x				
Aelurodon sp.	x					x	
A.(?) haydeni							
Cynarctoides sp.	x	x					
Carpocyon sp.	x			x	x		
Tomarctus sp.	x	x	x	x	x		
T. confertus	x		x	x	?		
"T." kelloggi	x	x	x				
Strobodon sp.				x			
Osteoborus sp.						?	
Felidae							
Pseudaelurus sp.			x	x			
P. aeluroides			x				
P. intrepidus	x						
P. cf. P. marshi		x		x	x		
P. sp. 1				x			
P. sp. 2			x				
P. sp. 3				x			
Ursidae							
*Hemicyon ursinus	x		x	x			
H. sp.	x		x		x		
Procyonidae							
Bassariscus sp.	x		x	x		x	
Mustelidae							
"Mustela" sp.	x			x	x	x	
Martes sp.			x				
Miomustela sp.			x				

	T-U	N	SR	P	CER/ OC	CH	Other
Mionictis sp.	x						
Martinogale sp.	x						
Plionictis sp.	x						
Plesiogulo sp.						x	
Pliotaxidea garberi						x	
**Pliogale* (?) *nambiana* (Cope)				x			
Sthenictis sp.	x			x	x	x	
INSECTIVORA							
Soricidae				x			
Talpidae							
Scalopus sp.	x						
Erinaceidae							
Metechinus amplior			?	x			
M. nevadensis			?	x			
cf. *Amphechinus*				x			
RODENTIA							
Beavers							
**Monosaulax pansus* (Cope)							
Dipoides sp.						x	
"*D.*" *williamsi*			?	x		x	
Eucastor cf. *E. planus*				x	x		
E. tortus			x	x	x		
E. cf. *E. tortus*	x						
?*E.* sp.					x		
E. cf. *E. curtus*	x						

Note: many other beavers have not been formally described yet

	T-U	N	SR	P	CER/ OC	CH	Other
Mylagaulidae				x		x	
Mylagaulus sp.				x		x	
Promylagaulus novellus	x		x	x	x		
Mesogaulus sp.			x				
Heteromyidae			x		x		
Cf. *Perognathus*				x			
Dipodomys cf. *D. hermanni*				x		x	
Geomyidae				x			
Schizodontomys sp.			x				
Cricetidae				x			
**Copemys loxodon* (Cope)				x			
LAGOMORPHA							
Lagomorpha, unidentified			x	x	x	x	
**Panolax sanctaefidei* Cope				x			
Hypolagus vetus						x	
EDENTATA							
Pliometanastes sp.						x	
P. (?) *galushai*						x	
NON-MAMMALIAN GROUPS							
BIRDS			x	x		x	
**Palaeoborus umbrosus*			x				

	T-U	N	SR	P	CER/ OC	CH	Other
REPTILIA				x			
turtle			x	x		x	
Testudo undata				x			
T. klettiana			?	x			
lizard			x	x			
snake?				x			
AMPHIBIA				x			
GASTROPODA				x			
"WORM TRAILS"				x			
WOOD			x	x	x		

TABLE 6. Numbers of various skeletal elements collected from Espanola Basin, 1942-1965. C = cranial; PC = post-cranial; H = horn; D = teeth. Because each C, PC, H, or D designation actually indicates a collection of these elements, numbering from 1 to 10, but probably averaging about 4, the total number of individual bones of each category may be grossly estimated by multiplying each number by 4. Note: some deer are probably antilocaprids. Identifications are field identifications as recorded on shipping invoices.

GROUP	C	PC	H	D	TOTAL	% of TOTAL
1. Camel	385	356	-	6	747	29%
2. Deer	222	117	148+	6	493	19
3. Horse	139	162	-	25	326	13
4. Rodent	209	26	-	8	243	9
5. Carnivore (undiff)	99	83	-	3	185	7
6. Antilocaprid	75	26	56	7	164	6
7. Rhino	48	47	-	3	98	4
8. Mastodont	35	37	-	19	91	4
9. Oreodont	33	25	-	1	59	2
10. Canid/Ursid/ Amphicyonid	17	12	-	1	30	1
Beaver	22	3	-	-	25	
Rabbit	13	6	-	-	19	
Reptilia(undiff)	5	12	-	-	17	
Mylagaulid	13	1	-	-	14	
Mustelid	11	2	-	-	13	
Insectivore	11	1	-	1	13	
unassigned mammalia	9	1	-	1	11	
Bird	-	7	-	-	7	
Felidae	4	-	-	-	4	
Edentate	2	-	-	1	3	
Peccary	1	-	-	-	1	

TABLE 7. Collections made by the A.M.N.H. during the Early Period (1924-1941). Tabulation is by field numbers. Each field number included collections consisting often of many boxes, sometimes of many different taxa. The large numbers from 1935 and 1936 are mainly collections from the Round Mountain Quarry (Santa Clara Pueblo), the largest quarry ever developed in the Santa Fe Group.

YEAR	NUMBER OF FIELD NUMBERS
1924	64
1925	250
1926	277
1927	152
1928	234
1929	193
1930	191
1931	144
1932	-
1933	113
1934	6
1935	722
1936	621
1937	272
1938	271
1939	110
1940	137
1941	55
1942 (pre-Galusha)	13

TABLE 8. Number of partial and complete skeletons collected during Early (1924-1941) and Later (1942-1965) periods by the A.M.N.H. Early collections are confined to the Espanola Basin; Later collections include the Espanola Basin but figures for the Jemez and Ceja del Puerco areas are given also.

GROUP	1924-1941	1942-1965			TOTAL (Espanola only
		Espanola	Jemez	Ceja	
Camel	79	34	13	4	113
Horse	6	8	1	1	14
Deer (& Antilocaprid)	9	4	1	-	13
Oreodont	7	3	7	-	10
Carnivore	7	2	1	-	9
Rhino	5	1	1	1	6
Mastodont	3	1	-	-	4
Turtle	1	3	-	-	4
Beaver	2	1	-	-	3
Rodent	1	1	1	-	2
Shrew or Rodent	-	1	-	-	1
Snake	-	-	2	-	-
Rabbit	-	-	1	-	-
Lizard	-	-	-	1	-
TOTAL	120	59	28	7	179

TOPOGRAPHIC MAP LOCALITIES

Fossil localities reported in previous work within and around the S.R.G.R.A. are summarized in the tables below. and are indicated on the topographic maps submitted with this report. The maps show all previous localities within the degree of accuracy allowed by the original report. By far the largest number of sites within the S.R.G.R.A. are in exposures of the Santa Fe Group, primarily on Espanola, Cundiyo, Lyden, Chimayo, San Juan Pueblo and Ojo Caliente quadrangles.

Various categories of localities are indicated in several colors on the maps:

red = boundaries of the S.R.G.R.A.

orange = localities identified to nearest section or fraction of a section.

yellow = general or imprecise localities, which generally contain several or many sites whose precise location was not recorded.

green = outline of areas containing type sections for specific stratigraphic units.

black = localities and numbers discovered during the field work for this study.

Until the 1940's it was not customary to designate localities with a high degree of accuracy, partly because accurate U.S. Geological Survey topographic maps and aerial photos were not available. Most of the yellow outlined "localities" are very general and refer to an entire range of hills or a wash system that undoubtedly contain several or many specific sites whose exact position did not appear in the records available to us. Some general localities that overlap with other general localities are not shown on the maps in the interest of clarity. Likewise, "localities" referring to large areas, such as

"Espanola" or "Santa Fe area" are of little use and are not indicated on the maps.

Santa Fe Group localities worked by the A.M.N.H. during the period 1924-1965 were often reported in relation to particular wash or arroyo systems. Most A.M.N.H. names for arroyos and other landmarks used informally in the field and in their records were not adopted by the U.S.G.S. for inclusion on their topographic maps of the Espanola area. Where possible, aided considerably by information in Galusha and Blick (1971), we have included A.M.N.H. names on the set of topographic maps showing A.M.N.H. localities. Some A.M.N.H. names, however, could not be tied to features on the maps, and these sites are omitted from the maps. Likewise, localities several miles away from the nearest S.R.G.R.A. land were omitted.

The set of maps showing previous localities also show about 80 sites discovered during our field work for this report. These sites are indicated by U.N.M. field numbers in black ink.

FIELD WORK

Introduction

Field work was carried out primarily in late July and August, 1978. Initially, a reconnaissance of the entire S.R.G.R.A. was made, in which all significant roads were driven. During this reconnaissance, information concerning type and extent of exposures, locations of important fossil deposits, ease of access to areas requiring intensive survey, conspicuous land use activities, and other observations were made that allowed further detailed planning of subsequent field work. Some areas, such as those covered by basalt or Precambrian exposures, were immediately identified during the reconnaissance as not requiring further survey for paleontological remains. Other areas were designated for intensive survey.

Because so much of the S.R.G.R.A. (i.e. all Santa Fe Group exposures) had been intensively prospected for fossils between 1924 and 1965 by the A.M.N.H., we regarded the main purposes of our intensive survey to be: 1) the selective survey of areas that had in the past yielded many fossils, in order to determine whether these beds were still productive; 2) survey of areas that looked promising based on their exposure pattern or stratigraphic position but where no significant fossils had previously been reported; 3) survey of the best outcrops representing all stratigraphic units within the S.R.G.R.A., to determine the main types of fossil assemblages present in each unit, or to verify the lack of paleontological resources in them; and 4) to document land use activities affecting or potentially affecting exposed sedimentary units within the area. Our intensive survey involved field crews of several individuals walking an area in close proximity, and examining exposures for paleontological remains. Every locality was described in detail, located precisely on a topographic map, and collections of representative material were made if the remains were not identifiable or if a sample of the remains was required to indicate their diversity. Material collected was taken back to the laboratory, catalogued and prepared if necessary. Such materials remain the property of the federal government, but are reposited in the University of New Mexico's paleontological collections. All pertinent information about each locality, regardless of whether material was collected, was entered on B.L.M. locality forms, included with this report (Appendix 4).

A total of 98 person-days was spent in the field; 12 by the Principal Investigators, 20 by the Field Supervisor, and 66 by students. All members of our field teams had extensive experience in paleontological surveying.

Our field studies were supplemented , in the case of the Santa Fe Group outcrops, by discussions with Mr. Ted Galusha, who directed fossil collecting operations in the Santa Fe for the A.M.N.H. from 1942 to 1965. Galusha also accompanied one of us (B.S.K.) in the field to examine important exposures in the Espanola area and to indicate particularly productive areas and stratigraphic horizons. His experience was especially valuable in helping assess the potential of some areas for yielding additional significant fossil remains.

Information gained during field activities is summarized and discussed in the sections that follow.

Nature of Exposures

The nature of surface exposures and lithologies present in an area will exert a strong influence on the presence or absence, abundance and quality of preservation of fossil remains. Normally only sedimentary rocks contain fossils but fossils may rarely be preserved in volcanic rocks and in Precambrian metamorphic and metasedimentary lithologies. The rarity of fossils in non-sedimentary lithologies means that exposures of this type may be ignored in paleontological studies. Considering only sedimentary rocks, their exposure patterns, hardness and lithology may affect greatly the amount of fossils available for study by paleontologists. For example, well indurated sandstones and limestones are often more resistant to erosion than shales, and form ridges or hills as the softer shales around them are eroded into valleys. Fossils may become exposed very slowly and gradually in hard sandstones, and be conspicuous, whereas fossils in many shales erode much more rapidly, become broken at a much higher rate, and are buried beneath a rapidly developing soil horizon that may support a dense vegetation cover. Rapid erosion of fossils within a shale, however, will also produce a better sample of the paleontological remains within the unit, if sampling occurs frequently enough to "harvest" the fossils before they fragment and become covered. The relative softness and cleavage features of shale often allow fossils to be sampled more readily from outcrops, than is the case with well indurated sandstones and limestones.

In many parts of the S.R.G.R.A. are basalt flows that cover the sedimentary rocks underneath and result in a topography of steep sided mesas and buttes held up by the resistant cap of volcanic rocks.

In such situations sediments may be exposed along the slopes, but usually these slopes are covered with volcanic debris eroded from the basalt cap. Though fossils may be present in the sedimentary units, most will not be exposed, and survey and sampling of the fossils may not be practical relative to the amount of time that must be expended. The same considerations apply to areas where sedimentary units have become highly eroded and covered with alluvium and vegetation.

Because the nature of the geologic exposures in any given area is an important determining factor in the amount of paleontological materials that will be present in the area, we summarize in Table 9 several general categories of exposure encountered in the study area. Additional comments about the topography, landforms, outcrops, geology and paleontological importance of all areas are presented for each U.S. Geological Survey 7½' and 15' quadrangle within the S.R.G.R.A. The paleontological importance of each quad was determined on the basis of both our field work and prior study by other groups. Reference should be made to discussions of previous work, the topographic locality maps, and to the summary of the paleontological resources presented in a later section, for data supporting our assessment of importance for any given area. A point to be emphasized from this information is that areas containing good exposures of sedimentary rock within the S.R.G.R.A. amount to about 23% of the entire area (see Table 9).

Mention of various divisions in the following quad-by-quad summary refer to the seven parts of the S.R.G.R.A. named in the introduction.

TABLE 9 . Exposure characteristics of S.R.G.R.A. land (numbers refer to sections, and are approximate)

Quadrangles	B.L.M. area	Metamorphic-Igneous	Quaternary alluvium/ Forested	Sedimentary-intermittent with Q_{Al}	Sedimentary-covered by Igneous	Sedimentary-Well Exposed	Paleontologic Importance
Bernalillo	17	-	10	2	-	5	low
Santa Ana Pueblo	25	17		5	2	1	low
San Felipe Pueblo	2	-	1	-	1	-	very low
Santo Domingo Pueblo SW	2½	2½	-	-	-	-	very low
Loma Machete	1	-	1	-	-	-	very low
Loma Creston	12	12		-	-	-	very low
Canada	15	7	1	2	5	-	very low
San Felipe P. NE	34	4	9	9	2	10	high
Hagan	24	-	11	7	-	6	moderate
Madrid (15')	6	-	6	-	-	-	very low
Tetilla Peak	19	4	13	2	-	-	very low
Turquoise Hill	½	½	-	-	-	-	low
Montoso Peak	7	1	6	-	-	-	very low
Agua Fria	27	-	27	-	-	-	very low
White Rock	6	1	3	1	1	-	very low
Horcado Ranch	31	-	-	29	-	2	low
Espanola	10	-	1½	2	-	6½	very high
Cundiyo	42	8	12	7	-	15	very high
Chili	26	15	2	9	-	-	low
San Juan Pueblo	8½	-	1	-	-	7½	high
Chimayo	41	3	24½	-	-	13½	moderate
Medanales	17	-	2	3	-	12	moderate
Lyden	35	2½	11	1	1½	19	high
Velarde	37½	10	7½	3	14	3	low
Trampas	39	25½	2½	-	5	6	low
Carson	18	12	2	1	3	-	very low
El Rito	15½	-	6	5½	-	4	low
Ojo Caliente	51	-	19	8	8	16	high
Boulder Lake(15')	5½	-	3½	1	-	1	low
Tierra Amarilla (15')	63	-	25	20	-	18	moderate
Navajo Peak	14	-	10	-	-	4	very low
Alire	33	-	10	18	-	5	low
Canjilon	10½	-	3	4½	-	3	moderate
TOTAL	695½					157½	

BERNALILLO - The southern and eastern parts of the Bernalillo division are flat or gently rolling topography consisting primarily of Quaternary alluvium with a few exposures of Tesuque equivalent strata (Santa Fe Group) appearing in arroyo cuts. To the NE of Highway 44 are dissected badlands and rolling hills of Santa Fe that represent apparently promising areas for fossil vertebrates, but no fossils beyond an occasional unidentifiable fragment of bones were found by AMNH collectors (Galusha, verbal communication). Our survey of these exposures corroborated the AMNH experience - we found nothing. A fossil sloth was reported from Pleistocene deposits in the west Rio Rancho area, west of S.R.G.R.A. land (Albuquerque Journal, May 1, 1978), suggesting that Pleistocene vertebrates may be present within the Bernalillo division. The present whereabouts of the bones and the exact site from which they were excavated are unknown at present.

SANTA ANA PUEBLO - The N and central parts of the Bernalillo division contain part of Santa Ana Mesa, a large landform capped by a relatively thin (220') basalt layer with an alluvium/soil horizon on top that supports grass and junipers. The basalt sits on Santa Fe sediments exposed only in the steep slopes; these slopes are mostly to entirely covered by basalt debris, and there is no record of any fossils coming from them. Jemez Canyon Dam sits near the mouth of a steep walled canyon cut through one edge of the mesa - essentially no exposures of Santa Fe are present in the canyon. Low rolling hills with intermittent badlands are present in the SW part of the quad, a continuation of the barren Santa Fe exposures present N of Hiway 44 on the Bernalillo Quad.

SAN FELIPE PUEBLO - The Bernalillo division barely enters this quad in the NW and SW corners. These limited areas include part of the top and slopes of Santa Ana Mesa. Santa Fe strata on the slopes are covered by basalt debris from the top. No fossils have been reported or were found during this survey.

SANTA DOMINGO PUEBLO SW AND CANADA - These quads include the Cochiti division. The NE half of this area contains rugged volcanic topography around steep-sided Peralta Canyon. A rhyolitic tuff and other flows cap the cliffs with a thickness of 50' or more. In the SW part some Santa Fe exposures appear in slopes and low eroded hills but these are both covered with coniferous vegetation and with volcanic debris. No fossils have been reported from this area and none are likely.

SAN FELIPE PUEBLO NE - The Hagan division occupies about the southern 2/3 of this quad, and is dominated by a high elongate N-S trending ridge composed of the Espinaso volcanics. At the base of this ridge, especially to the west, are badlands of Galisteo Fm that have yielded significant Eocene vertebrate fossils in a few places, including a titanothere bone bed ("Stearn's Quarry") where the Arroyo del Tuerto begins to cut through the Espinaso Ridge. E of the ridge, on both sides of State Highway 22, is a flat to low rolling area of Santa Fe Group that is exposed only occasional in arroyo cuts but generally is covered by Quaternary alluvium and pediment gravels. No fossils have been reported from or discovered in these exposures. In the extreme W part of the area are Cretaceous (Mancos, Mesa Verde) rocks, poorly exposed, that have yielded sparse marine invertebrate fossils similar to faunas found elsewhere in northern and central N.M. A U.N.M. graduate student, Tim Gorham, is studying the Galisteo in this area for his Master's thesis.

HAGAN - The southern part of the Hagan division occupies the NE 1/3 of this quad. A structurally complex basin occurs here, with good exposures of fossiliferous Cretaceous Mesa Verde Group, and barren Galisteo. The edge of a flat, vegetated mesa extends into the area from the SE and most exposures are along the slopes of this mesa. Extensive gently rolling hills having poorly exposed Santa Fe group mostly covered by Quaternary gravels comprise most of the northern part of the Hagan division on this quad. A wide variety of Cretaceous marine fossils and some coal beds have been reported from the Mesa Verde Group; a little petrified wood is known from the Galisteo. No fossils have been reported from the Santa Fe Group.

MADRID (15') - The Hagan division barely gets into the extreme W side of the Madrid Quad. Alluvium and gravel covered Santa Fe Group, lacking fossils, comprises the surface geology.

TETILLA PEAK - The southern part of the Santa Fe division occupies the NW 1/4 of this quad. Nearly all of this area is the Caja del Rio Plateau, capped by basalt and some Quaternary vegetated soil. Santa Fe Group is present beneath the basalt along the sides of the Santa Fe River Canyon, but these slopes are entirely covered by basalt debris. No fossils have been reported from this area.

TURQUOISE HILL - Just a sliver of the Santa Fe division is present in the extreme NW corner of this quad, and it contains basalt and some alluvium along Arroyo Calabasas. According to Walters (1969), there is a set of Pleistocene camel tracks near the cinder pit in section 17, but we were unable to locate them. These tracks were said to be under B.L.M. protection.

AGUA FRIA AND MONTOSO PEAK - Part of the Santa Fe division covers most of Agua Fria and the SE corner of Montoso Peak quads. This area is primarily relatively flat Quaternary sediment with no real outcrops of anything older. Most relief is in the form of eroded, basalt-capped hills. The topography becomes somewhat more dissected at the N end of Agua Fria map and here a few poor exposures of Santa Fe Group are present. No fossils have been reported from this area.

HORCADO RANCH - The N part of the Santa Fe division occupies about the SW 2/3 of this map. Intermittent exposures of the Santa Fe Group become more abundant through this area though the overlying Quaternary alluvium still predominates and it is much dissected by various arroyos. Two to three miles to the east of B.L.M. land, along U.S. Highway 285 in the Jacona and Tesuque Pueblo Grants, are the Cuyumungue and West Cuyumungue collecting areas that yielded much vertebrate material to A.M.N.H. collectors. The intermittent badlands within B.L.M. jurisdiction on this quad were prospected by the A.M.N.H. (Galusha, verbal communication, 1978) who did not find significatn remains. We also found nothing worth collecting in a brief time spent here, and feel that a finite, but low probability exists of significant vertebrate fossils being discovered.

WHITE ROCK - A few sections of the Santa Fe division are present in the NE 1/4 of this quad. The area is covered by basalt flows and is heavily forested; no fossils are to be expected.

ESPANOLA AND CUNDIYO - These quads include extensive Santa Fe (Tesuque) badlands between Nambe and Pojoaque Pueblos on the S and the Santa Cruz River on the north. This area is the most important for paleontological remains, of any in the S.R.G.R.A. Dozens of A.M.N.H. sites are here (including several quarries) that yielded collectively hundreds of bones and several skeletons of Mio-Pliocene mammals (see topo maps). Pojoaque Bluffs, another prolific collecting area, is just to the W of B.L.M. land and extends into it slightly. In addition, the type section for the Skull Ridge and Nambe Members of the Tesuque Formation are here, as part of one of the most complete continuous sections of this highly fossiliferous formation. We intensively surveyed areas N of White Operation Wash, along the south side of Arroyo Seco Wash and "Three Sisters", and around the type section for the upper Skull Ridge Member, and found enough additional material to suggest this area is still very fossiliferous. As one moves E in Cundiyo quad the quality of outcrop diminishes, so that about E of the Santa Cruz Reservoir. The hills become overgrown with vegetation and covered with Quaternary alluvium.

SAN JUAN PUEBLO - The extreme eastern side of this quad contains well exposed Santa Fe badlands within the Espanola division. This area is primarily the drainage of the First and Second Washes, which yielded numerous vertebrate fossils to A.M.N.H. collectors, and from which we obtained a rhinoceros jaw, several camel and deer jaws and much bone. In addition, the type location of the fossiliferous Espanola Formation (Pleistocene) is included here. A few miles to the W of B.L.M. land is the type section for the well studied, fossiliferous Chamita Formation, and 2 important quarries (San Juan and Lyden) are present in the Chamita just N and W of B.L.M. land.

CHILI - This quad includes some primarily alluvium covered Santa Fe exposures in the eastern and northern part of the B.L.M. area, but most of the southern and western exposures are volcanoclastics generally covered by alluvium, with some rugged mountainous topography. The Quaternary Puye conglomerate covers exposures on the extreme eastern part of the B.L.M. lands. Many good fossil localities in the Chama-el Rito Member were reported by A.M.N.H. collectors from this quad, along Rio del Oso and Dike Washes, but these are just N of the B.L.M. area, in the Juan Jose Lobato Grant. Few fossils have been reported from public land south of the grant.

CHIMAYO - The northern part of the Espanola division covers most of the southern 3/4 of this quad. Immediately N of Chimayo is an arc of excellent Santa Fe badlands (Skull Ridge Member) encompassing the drainage areas of Third through Seventh Washes. These badlands yielded a fair amount of fossil vertebrates to A.M.N.H. collectors. Terrain N of these badlands is heavily forested and covered by the Picuris re-entrant, an extensive coalesced series of alluvial fans of recent genesis.

MEDANALES - The eastern 1/3 of Medanales quad is included in the Ojo Caliente division, and consists of extensive to intermittent exposures of the Chama-el-Rito and Ojo Caliente Members of the Santa Fe Group. Several localities productive of fossil vertebrates are clustered around the Chama-el-Rito type locality, which is a few hundred yards W of the boundary between public land and the Lobato Grant. Our intensive survey in this area revealed that relatively few fossils are left on the surface.

LYDEN - The NW 2/3 of this quad are within the Ojo Caliente division. Most of this area is extensive badlands cut by numerous arroyos, and good vertebrate localities were reported by A.M.N.H. collectors along all of the wash systems W of the Rio Ojo Caliente, in the Chama-el-Rito Member of the Santa Fe Group. Our intensive surveys along Prince Ranch and Ojo Caliente Washes revealed relatively few vertebrate remains, but this large area retains a high potential.

VELARDE - The northern 2/3 of Velarde quad are in the Ojo Caliente division. Much of this area consists of plateaus of volcanic rocks (La Mesita and eastern tip of Black Mesa), and volcanic debris covers most of the Santa Fe exposures around the periphery of these structures. In the area around the town of Dixon, however, are limited good Santa Fe badlands exposures which have produced some vertebrate fossils for A.M.N.H. collectors.

TRAMPAS - The N 2/3 of Trampas quad are within the S.R.G.R.A., but sedimentary exposures (Santa Fe Group) are limited to perhaps the western 1/3 of the area, around the Rio Grande and Embudo Creek.

The remainder is heavily forested igneous and metamorphic rocks, including one of the few pegmatites in northern N.M. (site of the Harding Mine). Only a few vertebrate fossils were reported by the A.M.N.H., and we found none at all.

OJO CALIENTE - Nearly all of this quad is within the Ojo Caliente division. To the SW, and W of the Ojo Caliente River are good exposures of members of the Santa Fe Group, an extension of the area in Lyden Quad. Few fossils have been reported from these badlands, however, because they consist of poorly fossiliferous parts of the Chama-el-Rito, and the unfossiliferous Ojo Caliente Member, an ancient sand dune field. In the center of the quad the geology becomes complex, with volcanic plugs, several post-Santa Fe volcanic and volcanoclastic formations and Quaternary sands; fairly good collections were made NW of this complex in an outlier of Santa Fe badlands by the A.M.N.H. North, east, and northeast of the town of Ojo Caliente are rounded, forested hills of Santa Fe Group exposures and locally these have yielded significant concentrations of vertebrates to A.M.N.H. collectors. No fossils worth collecting were found in 2 areas intensively surveyed by our team.

CARSON - The northern-most extension of the Ojo Caliente division lies in the SE 1/4 of this quad, along the Rio Grande Gorge. Most of the area consists of high volcanic-capped plateaus with poorly exposed Santa Fe sediments along the debris-covered slopes down to the Rio Grande River. Some rhinoceros teeth were discovered in a site on a slope just outside the study area by a resident of Pilar, but this may be regarded as fortuitous, since the A.M.N.H. found no fossils here.

EL RITO - B.L.M. land covers the eastern 1/3 of this quad. Within this area is a long stretch of good dissected Santa Fe exposures (Chama-el-Rito/Ojo Caliente) which appear to be largely unfossiliferous, although a couple of sites having a few vertebrate remains are present, including one containing camel bones from the Abiquiu Tuff. Despite the attractiveness of the badlands, this area seems to have a low potential for fossils.

TIERRA AMARILLA DIVISION, INCLUDING BOULDER LAKE, TIERRA AMARILLA, NAVAJO PEAK, ALIRE, AND CANJILON QUADS - The topography in all of these quads is rolling intermittent hills and ridges of eroded Cretaceous marine rocks held up by resistant layers (e.g. Greenhorn Ls, Dakota Ss), and separated by valleys of alluvium. Higher elevations are forested and the valleys are covered by grass and shrubs; the percentage of exposed bedrock is rather small. Our survey verified that most of the Cretaceous shales and limestones contain marine invertebrates whereever they are adequately exposed in this area. The Dakota contains only traces of fossils where it is exposed, primarily as cliffs along the Chama River, and the underlying poorly exposed Morrison contains no fossils.

Paleontological Results of Field Work

During our limited field work a total of 80 localities yielding fossils were discovered (see Appendix 4 , and the topographic maps for site and location information). Almost all of these localities were in Santa Fe Group exposures and most were in areas previously reported as being fossiliferous by A.M.N.H. collecting parties. Fossils collected from our sites were identified by Lucas (vertebrates) and Kues (invertebrates), and the fauna from each site is recorded on the appropriate locality form (Appendix 4). No new taxa or previously unknown parts of described taxa were found.

Collections from our localities totaled several hundred specimens assigned U.N.M. (BUNM) catalogue numbers B-1500 to B-1635. Most of the remains are mammalian fossils from the Santa Fe Group, and these consist primarily of isolated bones and bone fragments, mainly limb and foot elements, and some teeth. The majority of Santa Fe remains were artiodactyls (camels, deer and antilocaprids), perissodactyls (horses and rhinoceroses), and small numbers of elephants, carnivores, turtles and other vertebrates. Several camel and deer jaws, a few horse and rhinoceros mandibles, and a nearly complete skull of a small camel were among the most noteworthy Santa Fe specimens collected (see Plate 4 for examples).

Significant differences were present in the amount of fossils found in various areas and stratigraphic units of the Santa Fe Group. Of the six subdivisions of the Santa Fe defined by Galusha and Blick (1971) we found the following:

Nambe Member - Prospecting in the upper part of the Nambe produced only occasional vertebrate fragments,

Skull Ridge Member - Prospecting in the Skull Ridge found it to still be highly fossiliferous, even producing excellent material including a skull and lower jaws of the camel Stenomylus. In general, fossil bone was associated with pale gree silty layers, some of which were laterally traced for nearly a mile. Most material was fragmentary but occasionally articulated and/or complete specimens were found,

Pojoaque Member - This member has been and continues to be highly fossiliferous. The occurrence of fossils is very similar to that in the Skull Ridge; in badlands of the Pojoaque just northeast of Santa Cruz ("First Wash") abundant bone was often associated with green silty layers of fair lateral extent. Many bones, including some jaw material came from this area.

Chama-el-Rito Member - Within the S.R.C.R.A. this member was sporadically fossiliferous at best. The fossils were once again associated often with green silty beds, but were fragmentary and low in abundance,

Ojo Caliente Sandstone - Prospecting within the study area, particularly just southwest of Ojo Caliente, where good outcrops occur, revealed only a few fragmentary fossils.

Chamita Formation - Very little Chamita crops out in the study area and it was found to be essentially devoid of fossils The few vertebrate fossils recovered once again were associated with green silty horizons.

Within the Pleistocene Espanola Formation near First Wash we found some bone fragments of mammals, and shells of pulmonate gastropods. Although many factors influence the abundance of fossils within a given sedimentary unit, our field observations correspond well with the 40 year collections of the A.M.N.H. relative to the abundance of fossils in each subdivision of the Santa Fe.

One factor of great importance influencing our field observations and collections in the Santa Fe Group, of course, is the previous collecting activity of the A.M.N.H. This intensive and continuous activity resulted in the periodic, sometimes yearly, resampling of many areas (Galusha, verbal communication, 1978). Collection of fossils has proceeded at a rate that far surpassed the rate at which fossils were being exposed on the surface by natural erosion. Thus, many areas containing units that are quite fossiliferous show rather little indication of fossil deposits now, due to the sometimes annual harvesting of fossils by the A.M.N.H. For this reason, a very detailed record of previous collecting activities, especially precise locations and stratigraphic information, is required to adequately estimate the amount of fossils remaining in the unexposed part of the strata. Existing surface fossil deposits are not valid indicators of subsurface deposits in places where extensive prior sampling has occurred

Comparing past records of collecting areas and our observations of present surface localities, we found that in many places A.M.N.H. collecting had essentially sampled all fossils exposed on the surface. In other areas, despite intensive collecting by the A.M.N.H., good vertebrate material was present on the surface, though not in the abundance apparent during the A.M.N.H. era. This difference in our success, in areas that presumably had been collected with equal effort, is partially due to the effects of differential erosion. Beds composed of well indurated sandstones or other well indurated lithologies have eroded very slowly in the 13 or more years since the last A.M.N.H. collections were made, and few bones have become exposed to view in that time. Softer beds have undergone considerable erosion in the last 13+ years, producing a relatively high number of weathered fossils on surface exposures. Identification of fossiliferous beds likely to erode at high rates to produce a constant "supply" of fossils would be a critical aspect of an extended field program to assess the paleontological potential of an area. During this study we were able to do this in only a few cases. For example, in the Skull Ridge Member within the study area, units of relatively poorly indurated siltstones and sandstones 0 to 40, 200 to 225, 260 to 290, and 440 to 480 ft above the base of the member (see Galusha and Blick, 1971, fig. 17) would be expected erode relatively quickly, producing more fossils than the equally fossiliferous "Red Wall" (40 to 120 ft), a massive, hard sandstone.

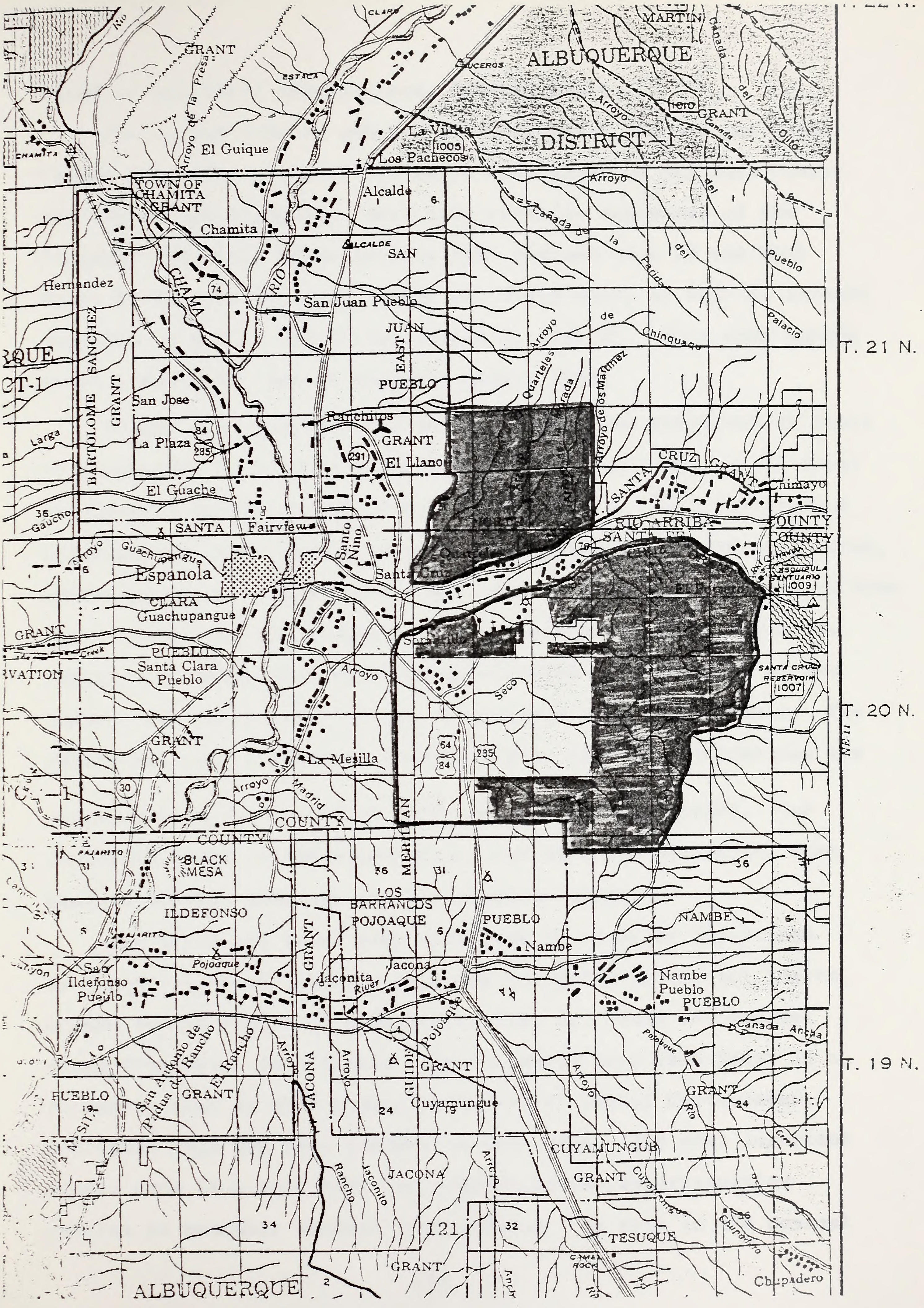
Two other factors are probably involved in explaining a paucity of vertebrate fossils in areas where there were several good A.M.N.H. localities. In some cases, there may have been (and still be) relatively few bones in that area or stratum; the A.M.N.H. collecting intensity was sufficient to discover and remove them as they eroded out, and insufficient time has elapsed since then to allow more to become exposed. In several other cases, where the A.M.N.H. found a dense but limited lens or pocket of fossils, their collectors simply quarried the entire deposit, removing essentially all bones present. Such dense accumulations of bone may develop initially by several processes, discussed later, and they may be distributed in an unpredictable fashion through a stratigraphic unit, necessitating constant surveillance during any large land use excavation.

Some of our field work in the Santa Fe Group surveyed areas of badlands from which the A.M.N.H. collectors had recovered few or no fossils. In all cases, our results were the same. This strongly suggests that the collecting records of the A.M.N.H. and particularly the distribution of their fossil sites are an excellent and very accurate indication of the true distribution of fossils within the several units of the Santa Fe. Places where there are no A.M.N.H. sites will almost certainly lack fossils, even if the lithology, topography and extent of exposure looks promising.

Areas of Special Concern

The section of this report outlining the geology of each quadrangle summarized in general the extent and importance of existing paleontological resources. Our field work revealed two areas within Santa Fe Group exposures in the S.R.G.R.A. of particular concern because they have numerous A.M.N.H. sites and good concentrations of bone present today as well. The most important of these is a large area in Espanola and Cundiyo quads, roughly between Pojoaque Bluffs on the west, the Santa Cruz River on the north, Santa Cruz Dam on the east, and the south boundary of the Espanola division on the south. This area covers about 24 sections, of which most is B.L.M. land, about 6 sections are State land, and about 3½ sections are private land (Fig. 7). Within this area are extensive exposures of the three most fossiliferous members of the Tesuque Formation, Santa Fe Group (Nambe, Skull Ridge, Pojoaque), the type sections for the Skull Ridge and Nambe Members (Plate 2, fig. B and Plate 1, fig. F), several dozen general and specific localities that have yielded numerous partial skeletons and thousands of bones, several quarries (Plate 2, fig. D), and for which the potential of future discoveries

FIGURE 7. Map of Espanola area showing the two portions of the Espanola division of the S.R.G.R.A. having important vertebrate fossils. Each area, but especially the southern one, are threatened by a variety of land use activities and the expansion of population in the area. Yellow = B.L.M. land; Blue = State land; White = private land.


ALBUQUERQUE
GRANT
DISTRICT-1
MARTIN
Canada del Ojito
Arroyo
Luceros
La Villita
Los Pachecos
El Guique
Chamita
TOWN OF CHAMITA GRANT
Alcalde
SAN JUAN PUEBLO
San Juan Pueblo
EAST
Hernandez
BARTOLOME SANCHEZ GRANT
RIO CHAMA
San Jose
La Plaza
Ranchitos
GRANT
El Llano
El Guache
Arroyo de la Parida
Arroyo del Pueblo
Palacio
Arroyo de Chinquaqua
Quarteles
Arroyo de los Martinez
SANTA CRUZ GRANT
Chimayo
RIO ARRIBA COUNTY
SANTA FE COUNTY
SANTA CLARA PUEBLO
Fairview
Santo Nino
Santa Cruz
Espanola
Guachupangue
GRANT
Santa Clara Pueblo
Sombrillo
El Potrero
ESQUIPULA SANTUARIO
SANTA CRUZ RESERVOIR
Arroyo Seco
La Mesilla
Arroyo Madrid
COUNTY
MERIDIAN
BLACK MESA
ILDEFONSO
LOS BARRANCOS
POJOAQUE PUEBLO
NAMBE
Nambe
Nambe Pueblo
PUEBLO
San Ildefonso Pueblo
Jaconita
Jacona
Pojoaque River
Canada Ancha
San Antonio de Padua del Rancho
El Rancho
JACONA
GUIDE
GRANT
Cuyamungue
CUYAMUNGUE GRANT
Arroyo Jaconito
Rancho
TESUQUE
Chupadero
ALBUQUERQUE
T. 21 N.
T. 20 N.
T. 19 N.

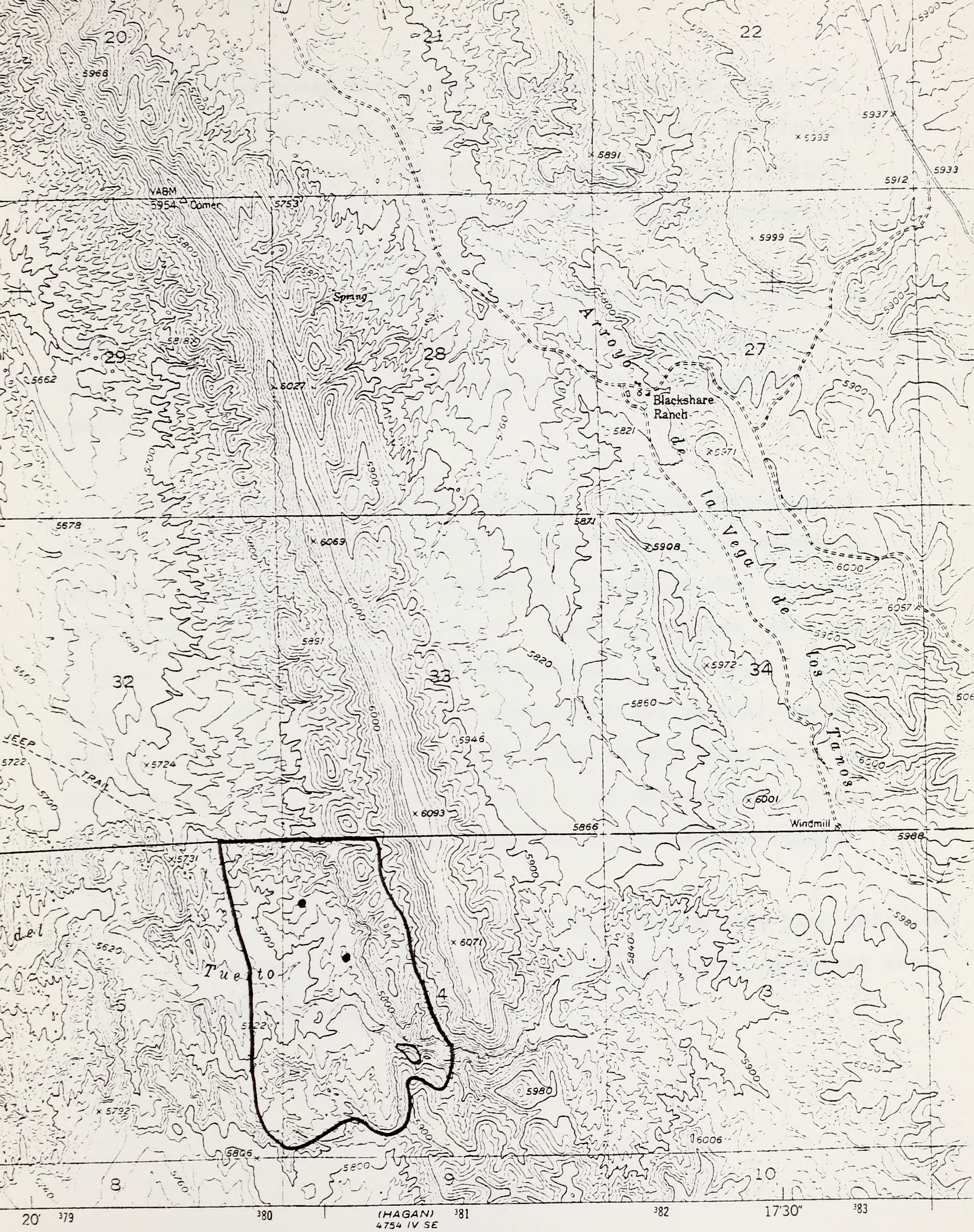
based on our field observations, remains great.

The second area of concern is along First, Second and Third Washes (Fig. 7), north of the Santa Cruz River on San Juan Pueblo and Chimayo quadrangles. This area contains exposures of the Pojoaque and Skull Ridge Members that yielded some of the best Santa Fe fossils we found during our field work, as well as several important A.M.N.H. localities (Plate 1, fig. E). This area covers about 6 sections, and is entirely public land.

Though the major part of our field work was conducted in Santa Fe exposures, we also surveyed fossiliferous outcrops of all other sedimentary units exposed within the S.R.G.R.A. Much Pleistocene alluvium and other sediments are also exposed within the study area, generally along rivers and streams, but few fossils are reported from them, and we did not actively survey these deposits. Vertebrate fossils are known from Pleistocene alluvium in most parts of New Mexico, but their distribution is sporadic and unpredictable. The nature and distribution of fossils within the other formations are summarized in the "Previous Work" section of this report. Our fieldwork added no new information, and with one exception, they contain fossils that are not particularly unusual.

The third and final area with fossils of major importance is a small area of Galisteo outcrops along the Arroyo del Tuerto, on San Felipe Pueblo NE quadrangle (Fig. 8). Here are several sites from which late Eocene fossil mammals have been found in a formation that in most places is barren of fossil vertebrates. Petrified logs are also present in this area. The most important single site is a thin bone bed containing the disarticulated remains of probably several titanotheres. As this is the densest

FIGURE 8. Part of San Felipe Pueblo NE $7\frac{1}{2}$' quadrangle showing particularly fossiliferous part of Galisteo outcrop (outlined in red), an area of concern because of a variety of land use activities that may soon affect this area.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27
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Arroyo de la Vega de los Tanos
Blackshare Ranch
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5908
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JEEP TRAIL
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6001
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Windmill
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FIGURE 8.

concentration of bones within the Galisteo, this bed should be excavated before any land use activity disturbs it. The fauna of the Galisteo is important because it is the only early Tertiary vertebrate fauna known in central New Mexico, and the formation appears to span the entire Eocene Epoch.

Each of the three areas of concern mentioned above have important fossil deposits that are threatened by various land use activities. Mitigation of this impact is discussed in the next section of this report.

Based on our field work and previous work, we were able to assign a level of importance to the paleontological resources in each U.S. Geological Survey topographic quadrangle that includes part of the S.R.G.R.A. (Table 9). These categories are a measure of past as well as potential paleontological importance. Implied in this scale is the assumption that every area has possible paleontological significance, for some fossils are rarely found even in volcanic and Precambrian rocks. Thus, a "no importance" category is not included in this scale. These levels of paleontological importance are as follows:

VERY HIGH - large numbers of important fossils have been collected in the past, and the area appears to have good potential for further important finds.

HIGH - many significant fossils have been collected in the past; the area will probably yield others after erosion has proceeded.

MODERATE - Some good fossils have been collected from several sites within the area and additional fossils seem indicated, though present distribution may be sparse (vertebrates), or areas having good assemblages of fossils that are widely distributed outside of the S.R.G.R.A. (invertebrates and plants).

LOW - A few significant fossils have been collected in the past, but the area seems barren at present. A small possibility of significant future discoveries.

VERY LOW - Few or no fossils known from area; generally applies to areas covered with Quaternary alluvium or volcanic material.

PALEONTOLOGY, LAND USE AND MITIGATION

Introduction

Many factors determine the paleontological significance of a particular deposit of fossils, and these factors must be defined for each site before land management decisions are made. In addition, there is a great variety of land use activities that affect or will affect various parts of the S.R.G.R.A., and each of these activities may influence the amount and type of paleontological information recoverable from a specific site. Thus, mitigation plans must be based on assesments of the interplay of these two sets of parameters - the affect of each possible type of land use activity on the various types of paleontological information contained in a deposit of fossils. The two endpoints to this complex continuum are, in general; 1) a situation where a fossil deposit contains little or no information that is not obtainable elsewhere, coupled with land use activities that minimally affect the deposits. Here no special mitigation would be necessary, 2) the other extreme would be a situation where a fossil deposit contains information, such as a very rare or previously unknown species, not present anywhere else in the world, coupled with a potential land use that would destroy the deposit. In this case, mitigation to completely preserve the deposit might be warranted. In the following discussions, we summarize those aspects of paleontological materials that provide paleontological information, the variety of possible land use activities observed within the S.R.G.R.A. and their effect on specific paleontological deposits, and finally, we provide suggestions for the mitigation of negative impacts on specific important sites within the S.R.G.R.A.

Nature of Paleontological Information and Mitigation Procedures

Fossil assemblages are scientifically valuable resources because of four different aspects of their use: 1) biostratigraphic interpretation, which allows rock units to be properly and accurately placed within the historical framework of a region, and in a larger sense of the earth itself; 2) paleoenvironmental interpretation, which allows deductions concerning the depositional environment of rock units and the paleoecology of fossil assemblages; 3) evolutionary interpretation, which allows the coherent understanding of the origin, radiation and in some cases extinction - i.e., the evolutionary history - of a group of fossil organisms; and 4) paleogeographic interpretation, which allows fossil assemblages to be related to contemporaneous assemblages in other locations. The mere fact that fossils are present in an area carries a certain amount of paleontologically important information; land use may increase or decrease this information.

The degree and type of mitigation required for a particular fossil site will be strongly influenced by several factors that affect the amount and kind of paleontological information that may be extracted from the fossils present. In general, there is a good correlation between the amount of information that will be lost during the course of land use activities, and the extent of mitigation that will be required to preserve at least some of this information. Four general factors are involved.

1) Nature of fossils and fossil assemblages. The fossils found within the S.R.G.R.A. fall into three main groups - vertebrates, invertebrates and plants. Invertebrate and plant taxa are similar in that they are usually small, consist of one or a few skeletal parts (invertebrates) or many similar replications of the same structure

(leaves, in plants) and are usually present in large numbers at a particular locality. Complete specimens are often numerous and easy to collect. Vertebrates are composed of 200 or more skeletal elements per individual that in most cases become disarticulated and scattered during transportation, deposition and subsequent erosion; thus most fossil vertebrates are known from incomplete skeletons. Vertebrate fossils may be difficult to collect because of large size (a single elephant bone may be a meter long and weigh dozens of kilograms), or because diagnostic skeletal parts (e.g. mammal teeth) may be too small to be observed by normal collecting procedures, necessitating special techniques such as bulk sediment screening. Thus, assembling a relatively complete picture of even a single fossil vertebrate requires the preservation and study of as many skeletal elements as possible, because even a single bone may provide information not previously available. A partially articulated vertebrate skeleton or accumulation of several complete bones may be a highly valuable discovery, whereas such remains of invertebrates and plants are not as commonly significant.

In addition to the type of fossil being an important determinant of mitigation measures, the associations of fossils are also important. Animals and plants have never existed in ecological vacuums; rather the pattern throughout geologic time has been the association of many different species into communities. Much modern paleontological study is centered around defining the nature and structure of paleocommunities, and the functional role of each taxon within them. "Fossil" communities are sometimes preserved, but they are relatively rare and most are as yet unstudied. Mitigation of such associations would be essential, even if the individual taxa involved were quite well known taxonomically. This is the case with some of the associations of more valuable than a site with mediocre specimens. Quality of preservation may vary considerably even within a single formation. Particularly with vertebrates, but also with plants, many taxa are known only from fragmentary or poorly preserved specimens; the presence of an exceptionally well preserved specimen at a site may make that site far more important than a site with average specimens.

2) Distribution and Abundance. The presence of a fossil or fossil assemblage may provide several other kinds of paleontological information that must be considered in assessing the scientific value of the site. Data on stratigraphic distribution, geographic distribution, intraspecific variability and relative abundance are all necessary to a complete understanding of a fossil group.

The stratigraphic range of a fossil organism is the tangible evidence in the rocks of the duration of its existence, and this record is usually incompletely known. Accurate determination and dating of geologic events in an area often depends on a precise knowledge of the stratigraphic ranges of fossils. In a larger sense, the entire geologic time scale is built on this basis. Moreover, because species change through time (evolve), samples at various points in their stratigraphic range provides the best data on their evolutionary rates and directions. Sites providing new information on the local stratigraphic ranges of its fossil species should therefore be adequately sampled.

The geographic distribution of a fossil taxon represents the spatial extent of that taxon during a particular time. Accurate sampling of geographic distribution is necessary for the interpretation of intraspecific variability and paleogeography of a species, and may add information concerning the composition and distribution of the paleocommunities of which each species is a part. Some fossil species, particularly marine forms, have a wide geographic range within a formation, so that loss of specimens in a land use area would not seriously deplete the total number of specimens available for study. Mitigation of such fossil deposits need be limited in many cases only to the obtaining of adequate samples of the species involved.

If a taxon has a distribution restricted to a limited area, a situation applying to many terrestrial organisms, the problem is more serious. Destruction of sites in this instance may mean the destruction of a large percentage of the total fossil record of the taxon. If restricted distribution is combined with low total numbers of specimens, there is a great necessity to collect as many additional specimens as possible before land use begins. Sometimes, where the occurrence of a fossil species is severely limited, localities yielding that species should be completely protected for future paleontological works, which may involved refined retrieval methods.

Similarly, localities from which type specimens have been designated should also be preserved as a matter of policy. Type specimens are reference specimens on which the concept of a species is based, and to which all other specimens considered to be within that species must be directly or indirectly compared. Destruction of a type fauna may obscure the concept of a species; if a type locality is not extant, new reference specimens cannot be collected, and the concept of the species cannot be thoroughly studied in the future.

The number of specimens available for study is an important factor affecting types of mitigation. A single specimen of a very rare species is clearly more valuable than a single specimen of a species known from thousands of other specimens. Though many species in the Santa

Fe Group are known from hundreds of specimens, some taxa are rare. The discovery of rare or previously undescribed parts of a species at a site adds considerably to the total knowledge of that species; sites producing such material are therefore sufficiently important to require salvage or preservation for additional information.

3) Degree to which fossils have been previously studied. The value of the paleontological resources in a given area is also affected by the amount of study they have received. The fossils of some formations in the western United States have received intensive, detailed study based on good samples; perturbation or destruction of new specimens of these fossils would not constitute a serious threat to our knowledge of the taxa involved, and the mitigation needed would probably be minimal.

The fossils of the Santa Fe Group have been collected nearly continuously for 40 years. Several groups have been studied intensively, but some groups have as yet received little study. Despite the great number of specimens available from exposures within the S.R.G.R.A., it would be advantageous to continue sampling, both to augment information on rare taxa and to add additional information about common species so that studies involving intraspecific variation and interspecific interactions may be as complete as possible. These considerations must be involved in mitigation programs devised for the Santa Fe Group in the S.R.G.R.A. Fossils in all other formations within the S.R.G.R.A. have received little or no study.

4) Nature of Land Use. The fossil resources of an area will be affected differently by different types of land use. Minimal use, such as grazing, will not have much effect on fossils; little information will be lost. Severe land use, such as strip mining, results

in severe disturbance and sometimes destruction of surface and near-surface fossil deposits. Thus, the type of mitigation required to preserve an adequate amount of paleontological information depends strongly on the kinds of land use the land will be subjected to. The effects of land use observed within the S.R.G.R.A. are considered in detail in a later section of this report.

The degree and type of mitigation appropriate to a site is influenced by the nature, importance and number of fossils present, techniques available or feasible, type of land use anticipated, and the extent to which the sampling procedures can preserve paleontological information. In many areas mitigation will involve a survey of fossil deposits and selective sampling of the fossil remains. The importance of the fossils will to a large extent determine the degree of sampling. Deposits containing new, rare, or unique fossils must be sampled as thoroughly as possible because every specimen may be important. This may involve the collection of every specimen on the surface as well as large scale excavations and/or screening operations, and may need to continue for a relatively long period of time.

In other cases, mitigation involving sampling will not require the collection of every specimen at a site. Parts of fossils that provide the most information, such as the skulls and teeth of vertebrates, hingelines of bivalves and leaves of plants, should be collected preferentially where available. Samples that adequately document stratigraphic and geographic distribution, biotic associations and variability are sufficient for other fossil remains. An adequate sample will depend on the type of fossil present and the extent of previous collections, but each site must be judged independently. Fossils that offer little or no additional information need not be sampled at all.

While sampling of the fossils themselves will be the main concern of any salvage program, other aspects of the geology of a locality may also aid the total amount of paleontological information available, and therefore should be sampled. Stratigraphic and sedimentological information help to define the conditions in which the fossils were deposited, including their taphonomy and any concentration mechanisms that may have been operating. Paleomagnetic samples are useful in refining absolute ages of fossil deposits. Petrographic study of fossil bearing sedimentary rocks may also add information on depositional and post-depositional processes, as well as indicating source areas for the sediment and fossils and providing paleogeographic information. Sampling of a fossil locality would also include sampling of these features of the geology on an as-needed basis.

Many techniques are available to sample fossils before or during land use activities, ranging from surface collecting and small scale excavations to full scale quarrying operations in places where large concentrations of fossils exist. In some areas, such as many units of the Santa Fe Group, fossils continually erode out of the strata, and periodic surface collecting of the same exposures is the best way to sample the fossils. This method was used with great success by the A.M.N.H. Screening of large amounts of sediments for small vertebrate fossils productively samples small remains that might go unnoticed otherwise. Relatively little screening has been done on any of the fossiliferous units within the S.R.G.R.A., and this should become a part of any subsequent sampling programs at appropriate sites.

Silicified wood, such as exists in large amounts in Galisteo exposures, can be sampled by removing entire logs or by sampling a small fragment that preserves the internal cell structure of the wood and thus will allow precise identification. The latter method is sufficient in most cases, but entire logs should be removed if they would otherwise be destroyed during land use activities.

Areas having highly important fossil deposits, type sections for formal stratigraphic units, sites from which many new taxa have been described, and deposits that would best be sampled by programs lasting several years should be preserved, if possible, by not allowing land use activities that would result in non-paleontological excavations. These areas, paleontological preserves, would thus preserve unique areas as reference sites for geologists and paleontologists, allow the systematic and careful collection and study of fossils in the area, and allow the study of _in situ_ relationships that would be disturbed by land use or rapid salvage programs. Two of the three areas in the S.R.G.R.A. mentioned earlier as being of great concern could be considered potential paleontological preserves. These areas have extensive fossiliferous Santa Fe Group exposures and are present directly north and south of the Santa Cruz River (see Fig. 7).

Specific recommendations for mitigation of paleontological sites within the S.R.G.R.A. are presented in the next section, where the relationships between paleontological resources and types of land use observed within the S.R.G.R.A. are discussed more fully.

Land Use

A major emphasis of the field work was to observe and document land use activities within areas having paleontological resources. With such observations, the existing or potential impact of land use on paleontological remains could be assessed and suggestions for mitigation made. Almost every type of possible land use activity has some effect on fossils, the effects range from strongly destructive through insignificant to strongly productive of new information.

Major types of land use activity encountered within the S.R.-G.R.A. included 1) grazing by sheep and cattle, 2) associated activities related to grazing, such as fencing and stock tank construction, 3) roads, 4) off-road vehicle trails, 5) gravel quarries, 6) dams, 7) power lines, 8) gas and water wells, 9) effects of urban expansion, including a variety of associated land uses, such as clearing and excavation of land, building of houses and other structures, increased concentrations of roads, powerlines, trash dumps and the other direct and indirect impacts of having numerous people in an area where few were before, and 10) surface mining activities. Each of these activities will be analyzed in detail below.

1) Grazing. Land use associated with grazing generally has little negative impact on fossil deposits. Erosion by the movement of stock will normally not affect outcrops of well indurated sandstone, shale or limestone, because these are exposed generally as ridges or relatively steep-sided hills. Grazing itself is limited mainly to vegetation-covered alluvium that contains few or no exposed fossils. With a few exceptions the fossils present in

the alluvium have been transported by natural erosion away from the original outcrop, with the corresponding prior loss of much paleontological information. Similarly, areas of "badlands" topography which are present in many parts of the S.R.G.R.A. and elsewhere and comprise highly eroded fields of hills or ridges cut by numerous arroyos, receive no impact from grazing because cattle and sheep do not normally traverse such exposures. The effects of grazing are perhaps more strongly felt in rock units of soft fossiliferous shale that weather readily to gentle slopes and valleys. In such cases the activities of stock animals might increase slightly the erosion rate but the negative impact on the fossils would be minimal - probably limited to the occasional destruction of an eroded specimen.

Grazing is carried on in almost all parts of the study area where vegetation and topography are appropriate. Probably the most significant grazing area was in the well watered Cretaceous shale valleys of the Tierra Amarilla division. The most severe impact on an outcrop observed here was a much used cattle trail that ran over a low Mancos Shale outcrop near the Nutrias River. Surface disturbance extended to a depth of about 5-10 cm and some marine fossils had been kicked up and fragmented. Because the surface disturbance affected a minute part of the total fossiliferous outcrop, the direct activities of the cattle are of little concern from a paleontological point of view. Certainly, trying to mitigate this kind of disturbance would be senseless.

2) Human activities associated with grazing. Fencing, constrution of stock tanks, corrals and small access roads involves to some extent the excavation and removing of land from one place

to another, and thus has a more significant potential impact on fossil deposits than the natural processes of erosion. In our experience most of these activities occur in and affect the same areas as the grazing, namely vegetated alluvium in which there are few or no in situ fossil deposits. Construction of a stock tank might seriously disturb a fossil deposit only if that deposit is of very limited extent, or contains rare types of remains. Such situations should be noted in paleontological surveys of an area, and stock tanks should not be built in areas previously identified as having highly significant fossil deposits. No sites within the S.R.G.R.A. were disturbed by stock tank construction. Fencing is a less severe form of land use impact and because it affects so little of the surface in an area, would not be expected to disturb paleontological deposits significantly. One effect of fencing is to decrease access to an area, particularly if gates are locked. While this may make it more difficult for a paleontologist to enter the area to examine or study the fossils, it also limits access by casual collectors and thus preserves paleontological information. The net effect on the paleontological resources will probably be positive, because normally the casual collector will be discouraged by these limitations of access whereas the paleontologist will not be. Access roads into grazing areas have the same effects, on a smaller scale, as the construction of major roads, which will be discussed below.

3) Roads. Roads have several major direct and indirect effects on paleontological resources. Road construction, particularly the construction of a major paved road through fossil-bearing outcrops, will result in the significant excavation of

rock. The potential for damage or destruction of fossils and a disruption of stratigraphic and association information is great. This must be balanced, however, against the very positive result that the excavations will reveal subsurface deposits that would not have ordinarily been available for the scrutiny of the paleontologist, thus increasing the amount of paleontological information available in an area. Paleontology has long benefitted from the activities of road builders in producing road cuts that show fossil deposits and stratigraphic/sedimentological features that would otherwise have gone unrevealed. In terms of the direct effects of road-building on paleontological information, the consensus among paleontologists (at least in the author's experience) is that although some fossils may be damaged and paleontological information lost, the information gained by being able to observe roadcuts far outweighs the information that is lost. This statement is true in most areas having fossil deposits. However, it must be remembered that in areas having paleontological remains of demonstrated great importance, the only excavations desirable are those by paleontologists.

The negative direct impacts of road building can easily be mitigated by having paleontologists survey a proposed road site before construction begins, and return periodically during contruction to monitor the paleontological materials being disturbed. In New Mexico and many other states this is routinely done by the State Highway Department for archaeological remains along all state roads (Steve Hoagland, New Mexico State Highway Department, verbal communication, October 1978), because of state laws (Cultural Properties Act) requiring it. Paleontological materials could and should be surveyed and monitored in the same way, though this will probably only be possible with the passing of appropriate legislation. We presume that there would be no problem with federal agencies involved in highway construction, working with state agencies to obtain paleontological clearances along proposed road sites.

The indirect impacts of road-building are also highly significant. Increased numbers of roads into an area of important paleontological resources allows increased access by amateurs and commercial fossil-hunters. This can result in a greatly accelerated rate of theft of important paleontological materials from public lands. Perhaps even more significantly, the indiscriminate collecting of fossils by untrained people causes the irretrievable loss of much important paleontological information connected with the location, stratigraphic position, orientation, and associations of the removed fossils. Many cases are documented where commercial dealers have entered an area and effectively destroyed the fossil deposit and nearly all the scientific information that might have been retrieved. This activity was the impetus, for example, for the creation of Petrified Forest National Park, Fossil Buttes National Monument and others.

Solutions to this problem involve the increased education of amateurs, the close regulation of commercial dealers, the limitation of off-road access to important fossil areas and the establishment of protected parks and preserves where the public may view fossils without being able to remove them. Detailed discussion of all aspects of this problem are beyond the scope of this report. We emphasize, however, that the problem must be considered by land managing agencies and some reasonable methods developed for handling it in a manner equitable both to scientists and to the interested amateur collector. The problem is not only connected with road building but enters into nearly all land use activities, such as mining and increased urbanization, that allow or encourage greater access to areas with significant paleontological resources.

Roads of various kinds and for various purposes are common in the S.R.G.R.A., and many roadcuts through highly fossiliferous units are present. Aside from the general suggestions for survey and monitoring of paleontological resources made above, we also add that creation of additional roads ought to be discouraged in the areas we have identified as being of great paleontological importance, because, in our view, the cumulative negative direct and indirect effects outweigh the advantages to be gained by road building activities in revealing new fossil deposits.

During the course of this study it was learned that the New Mexico State Highway Department was assessing some possible alternatives with respect to elevating a section of U.S. Highway 85 between Albuquerque and Santa Fe to federal interstate highway standards and thus completing Interstate 25 between the two cities. Five of the seven alternatives being considered assumed an improvement of the present route that cuts through a small and unfossiliferous part of the Hagan division of the S.R.G.R.A. Two alternatives (see map, Fig. 9 , and Appendix 5), however, are to change the present route by constructing additional segments in the parts of the Hagan division indicated on the map. The alternative #6 route runs just inside of and parallel to the northern boundary of the Hagan

FIGURE 9. Map showing alternative routes for Interstate 25 that cross the Hagan division of the S.R.G.R.A. Alternative # 7 crosses the Arroyo del Tuerto almost exactly at the place where several vertebrate localities in the Galisteo Formation are known.

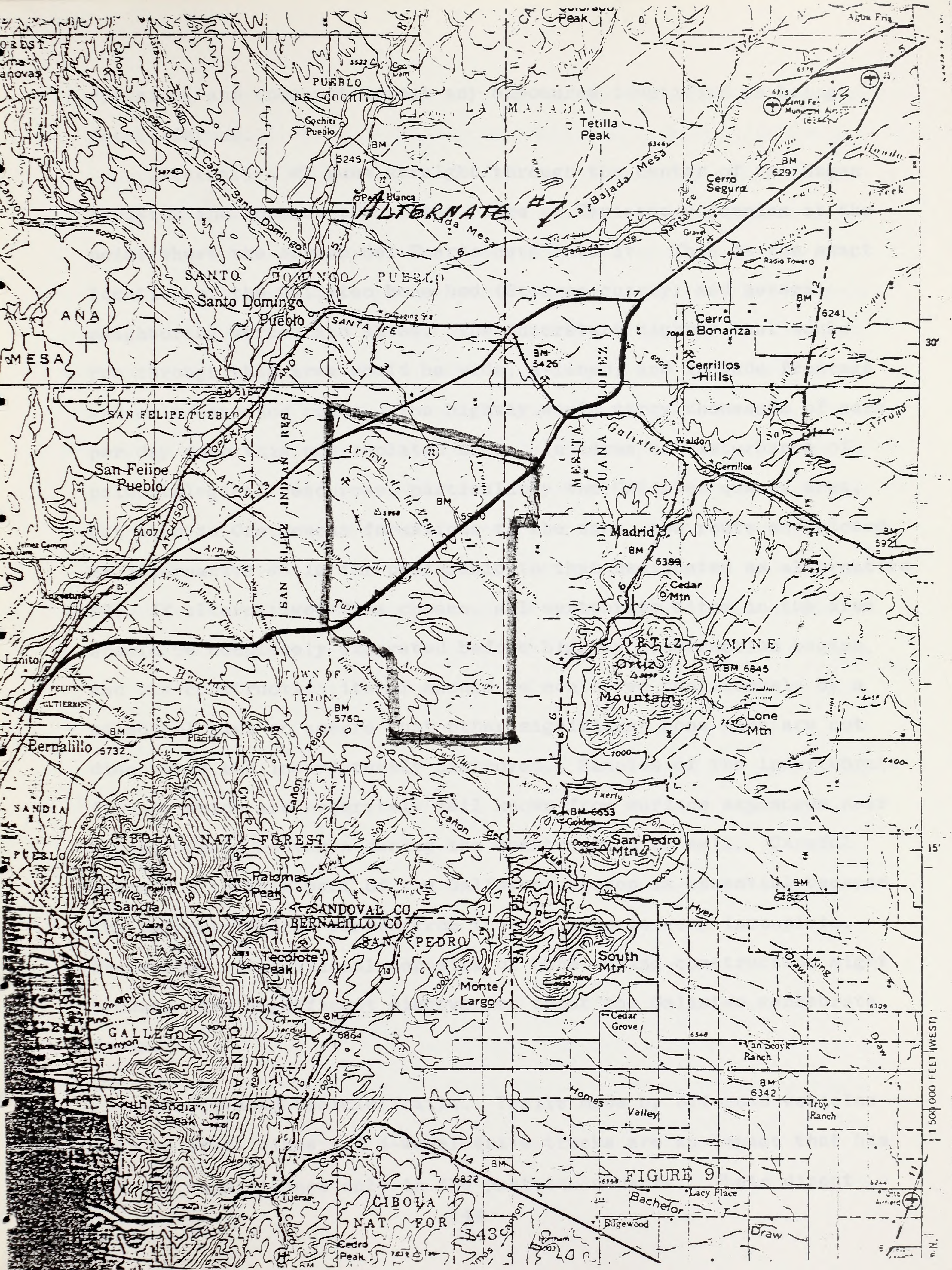

ALTERNATE #7
PUEBLO DE COCHITI
LA MAJADA
Tetilla Peak
Cochiti Pueblo
La Bajada Mesa
Cerro Segura
Santa Fe Municipal Airport
SANTO DOMINGO PUEBLO
Santo Domingo Pueblo
Cerro Bonanza
Cerrillos Hills
SAN FELIPE PUEBLO
San Felipe Pueblo
SAN FELIPE INDIAN RES
MESITA DE JUANA LOPEZ
Waldo
Cerrillos
Madrid
Cedar Mtn
ORTIZ MINE
Ortiz Mountains
Lone Mtn
TOWN OF TEJON
Bernalillo
Placitas
CIBOLA NAT FOREST
Golden
San Pedro Mtn
Palomas Peak
SANDOVAL CO
BERNALILLO CO
SAN PEDRO
Sandia Crest
Tecolote Peak
SANDIA MOUNTAINS
South Mtn
Monte Largo
Cedar Grove
Van Scoyk Ranch
Gallego Canyon
South Sandia Peak
Homes Valley
Irby Ranch
Tijeras
CIBOLA NAT FOR
Cedro Peak
Bachelor Draw
Lacy Place
Edgewood
30'
15'
1 500 000 FEET (WEST)

FIGURE 9

division, and does not affect any exposures identified as being fossiliferous.

Alternative #7 runs straight through the center of the Hagan division and appears to cut the ridge of Espinaso volcanics at the point where the Arroyo del Tuerto cuts into it. This is the exact location of the Galisteo bone bed (Stearns quarry) and several neighboring vertebrate sites. The interstate highway that would run through this area would be wide, 4-laned, and include frontage and exit/entrance roads. The highway would carry thousands of cars per day into this now-isolated area. In terms of disturbance of paleontological resources, particularly the Galisteo quarry area, but also in Cretaceous formations to the east, the route envisioned as alternative #6 is far preferable to that designated as alternative #7. If alternative #7 is chosen, all vertebrate sites in the area should be completely excavated before highway construction begins, and the construction itself should be monitored continuously by a paleontologist to assure that other significant bone beds are not discovered and inadvertently destroyed. Samples of the invertebrate faunas, which are moderately well known from surface exposures near Hagan, should be taken during the construction as well. Careful attention to this part of the Galisteo outcrop is essential because the paleontological record from the Galisteo is very incomplete. Uncovering of additional deposits of bone during construction might produce very significant discoveries about the Galisteo vertebrate fauna.

4) Off-Road Vehicle Trails. Trails made by off-road vehicles such as trail bikes and 4-wheel drive trucks are an impact that has assumed significance only in the past two decades. Their direct

impact on paleontological resources has been relatively small so far, but the use of such vehicles is increasing. The trails themselves disturb surface exposures, and cases are known by the authors of truck trails going over exposed fossils. This type of land use is made more serious by the fact that badlands areas, which often have soft, easily erodable fossiliferous sediment on the surface of the exposures, are easily accessible to off-road vehicles and in fact seem to be preferred, judging from the distribution of such trails in the S.R.G.R.A. When a heavy concentration of vehicles continually uses an area, surface exposures of softer lithologies are severely eroded and the fossils within them may be destroyed.

An important indirect effect of off-road vehicles results from the fact that they can go into areas previously inaccessible except by horse and on foot. Thus their use may bring important fossil deposit into the range of non-paleontologists, with the potential negative effects described above in the discussion on roads. If the off-road vehicle user is not looking for fossils, he may damage deposits by unknowingly driving over them. The effect of off-road vehicle use is cumulative; one vehicle driving around in an area probably does little direct or indirect damage to fossils, but hundreds of such vehicles driving in an area over a short period of time might do significant damage. The latter is an increasing possibility as the use of off-road vehicles increases.

We encountered off-road vehicle trails in several parts of the S.R.G.R.A. Usually they were isolated, but in two areas they were somewhat concentrated - in the Santa Fe badlands north of Bernalillo and in the "Three Sisters" area just east of U.S. highway 84/285 immediately south of Arroyo Seco. In the former area, paleontological impact is negligible because of the scarcity of fossils in these deposits but the "Three Sisters" area is within a large area of Santa Fe badlands having important fossil vertebrates. The combination of direct and indirect impacts here could result in disturbance of the fossil deposits if such use intensifies. Though we cannot document the actual destruction of paleontological information by off-road vehicle use, the possibility of damage exists. We also point out that this type of land use damages other more conspicuous resources, such as botanical, zoological, archaeological and aesthetic resources. If all aspects of this problem are considered, including the need for people to enjoy unpopulated areas, some regulation of off-road vehicle travel seems to us to be required if it is not to become a major negative impact on surface resources in some areas.

5) Quarries. Quarries are pits excavated into surface exposures of sediment or rock, from which earth material is removed. As the operation progresses the area of excavation becomes larger, although all quarries encountered in the S.R.G.R.A. are no more than a few acres in extent. Depending on the the type of rock being excavated and the type of fossil deposits in the area, the impact of a quarry operation on paleontological information may be slight or severe. By exposing subsurface strata and fossils, and by piling up debris in or near the quarry, quarry operations may aid paleontologists. For example, much information about lower Paleozoic reefs in the Midwest comes from examination of quarries that are excavating limestone from the reef deposits. On the other hand, information is lost by the disruption of stratigraphic position and associations of fossils. If fossils are present in the rock that is being quarried

they may be destroyed as the rock is ground up or transported for use elsewhere. As with many types of land use involving beneficial as well as destructive aspects, each case must be judged separately in determining the need for mitigation and the mitigation program appropriate to the situation. Several examples come from quarries within the S.R.G.R.A.

Quarries within the S.R.G.R.A. are primarily small sand and gravel pits excavated into Quaternary pediments and alluvium generally near the larger stream and river valleys. The number of these pits and the amount of material quarried is impressive - nearly 700,000 tons of sand and gravel from Rio Arriba County alone in 1965 (Bingler, 1968). Most of this is used in concrete for buildings and as road metal. Quarry activity and production would thus seem to be correlated with the population growth that requires both new buildings and new roads, locally. In a few places pits have been dug into Pleistocene basalt flows (NW corner of Turquoise Hill quad), or excavated into older sedimentary rock (near Cerito Pelado, Montoso Peak quad). The quarries excavating gravel are generally working in a sedimentary environment involving large clasts that was not particularly condusive to the preservation of fossils, and few are encounter Occasionally, however, remains of Pleistocene mammals are found in gravel pits in New Mexico; these remains are usually of large skeletal parts that have survived the high levels of abrasion and fragmentation that characterize coarse-grained depositional environments.

In cases where fossils are found in quarries, it should be recognized that the reporting of significant fossil remains will depend on: 1) the quarry supervisor and workers being informed as to what is wort reporting, 2) the development of an atmosphere of mutual respect betwe public agency and quarry owner, so that the quarry owner or worker will choose to report an unusual fossil discovery, and 3) the presence within the local agency or paleontological institution of people trained in paleontology who could inspect a discovery and assess its significance with little delay after it is reported. It is obviously not practical to continuously monitor each quarry for paleontological material; the voluntary cooperation of quarry personnel in reporting such materials must be cultivated. The visit of a paleontologist periodically to observe the progress of the quarry and inspect spoil piles for indications of significant fossil remains would insure that some paleontological information could be retrieved, even if the quarry workers were apathetic to paleontological resources. Mostly for practical reasons, then, the development of a program of education and voluntary cooperation for small scale quarry operations coupled with periodic observations by paleontologists would result in an adequate amount of information on paleontological resources within the quarry being relayed to land managing agencies.

Quarries in lithologies from which fossils would not be expected, such as basalt flows, should be ignored in paleontological mitigation plans. Very rarely fossils of interest may occur, such as the Pleistocene camel tracks in the Turquoise Hill quad basalt flows, but their existence is entirely fortuitous and cannot be predicted. Land management agencies can reasonably assume that such deposits lack paleontological materials, unless interested individuals report their presence.

6) Dams. Dams may directly influence paleontological resources in an area if: 1) the material out of which they are constructed is excavated from fossiliferous rocks nearby, 2) the dam itself covers fossil bearing rocks, and 3) the water held by the dam covers fossiliferous strata. The first case is basically a quarrying problem, and the suggestions made in the previous section apply to it. Comments relating to the other two impacts will be made in the following discussion of the dams in the S.R.G.R.A.

In the S.R.G.R.A. are two dams of moderate size, the Jemez Canyon Dam (Plate 1, fig. B) in Santa Ana Pueblo quadrangle, and Santa Cruz Dam, in Cundiyo quadrangle. Jemez Canyon Dam is near the mouth of Jemez Canyon, a steep walled structure that cuts through a side of Santa Ana Mesa. The walls of the canyon are Santa Fe Group, covered by basalt debris eroded from the volcanic cap of the mesa. Because no reservoir is developed behind the dam, and the dam itself covers only a small area of unfossiliferous basalt covered slopes, the construction and present operation of the dam very probably does not affect any paleontological resources.

Santa Cruz Dam is built on Precambrian granites, but exposures of the Nambe Member, Tesuque Formation, nonconformably overlie the Precambrian, and the reservoir extends over some Nambe exposures. Only the lower unfossiliferous parts of the Nambe are involved, however, so the dam and reservoir do not appear to adversely affect any paleontological resources.

Several small earth-fill dams are also present within the S.R.G.R.A. The largest and most conspicuous of these is across White Operation Wash. It seems to be constructed from arroyo floor alluvium and not from material excavated from the surrounding badlands, and so it has no direct impact on the fossiliferous exposures nearby. No reservoir was associated with this dam during the time of our study. We do not know who constructed dam, but it may be interpreted as a signal of increased human activity in this very important vertebrate fossil bearing area.

In the construction of other dams on B.L.M. land, particularly in areas determined to have fossil deposits, a thorough survey of the paleontological resources should be required. This would include the site of the dam, associated buildings, spillways, and the surrounding area that would be covered by a reservoir.

7) Power Lines. Power lines, particularly near populated areas, are a conspicuous feature in many parts of the S.R.G.R.A. The construction of new lines may be expected to continue, both as a result of increased population and potential mining activities. Construction of power lines involves some surface disturbance of exposures as well as the excavation of roads along the route. Survey of proposed power line routes and possible salvage of fossils disturbed by construction activities would be necessary to mitigate the relatively minor impacts that would result. In poorly fossiliferous exposures, and exposures having assemblages of fossils well known from adjacent areas, no special mitigation beyond the initial survey would be required. If the power line route lay over limited outcrops having rare or unique fossils, alteration of the route might be required. Individual surveys of each route, such as have been done on recent surveys in New Mexico, would define the level and type of mitigation required. We found no evidence that power lines are negatively impacting paleontological resources in the S.R.G.R.A.

8) Gas, Oil, and Water Wells. Although oil, gas and water wells individually occupy relatively small areas, and thus have rather minor impact on surface exposures,heavy equipment is generally required to erect them, and the area affected by this equipment may be many times the area of the well itself. For this reason it would be prudent to survey to survey areas of prospective well sites for surface fossil deposits, salvage samples of any assemblages that might be affected, and if possible restrict well sites to exposures lacking fossils.

We observed few oil and gas wells within and adjacent to the S.R.G.R.A.. The geologic environment in this area appears to be unfavorable for petroleum accumulation, and at present the development of large numbers of wells in the S.R.G.R.A. does not appear imminent.

Water wells are common, and being small, do not have a major impact on the land into which they are drilled. The chances of a singl well severely disturbing the paleontological resources of an area are very small. As a general rule, we suggest that areas having a high concentration of water wells (perhaps more than 5 per acre) be examined for fossils once, to document their presence or absence in the area. We do not anticipate that detailed sampling of the fossils near a well will normally be needed. Water wells in the S.R.G.R.A. had no adverse impacts on paleontological resources.

9) Urban Expansion and Population Growth.

Introduction. Urban and semi-urban expansion, resulting from an influx of population to an area and manifested in the excavation of home and building sites in areas that were previously unoccupied is perhaps the most severe type of land use currently proceeding in some parts of the S.R.G.R.A. Besides the direct impact of these activities, they bring with them an expansion of the road network, addition of such facilities as power lines and trash dumps, and an increased number of people with access to areas where few persons ventured before. Areas with important paleontological resources may consequently be disturbed by the combined effects of new land utilization and the activities of people brought into the area where this is occurring.

Santa Cruz River-Arroyo Seco-White Operation Wash Area.

Though most parts of the S.R.G.R.A. are relatively distant from centers of population, and some areas are nearly inaccessible and uninhabited, significant population growth is or soon will be affecting several parts of the S.R.G.R.A. having important paleontological resources. The areas of greatest impact are two narrow strips south and east of Espanola (see Fig. 7). The area south of Espanola extends along U.S. highway 84/285 from the north boundary of the Pojoaque Pueblo along Joe Rak Wash and Arroyo Seco to Espanola. Much of this distance is within the Espanola division of the S.R.G.R.A. The strip east of Espanola is the Santa Cruz River valley, which projects like an arm into the Espanola division, although it is not included within it. Parts of this area, particularly along the Santa Cruz-Chimayo road, have high population densities within a few hundred yards of public lands. Espanola, by far the largest town in the vicinity, is about 2 miles west of the boundary of the Espanola division.

The evidence of significant population growth in these two areas is easily observed in the field. We are not qualified to document in detail the magnitude and direction of population growth radiating from the town and suburbs of Espanola, but a few comments can be made. We observed that many of the buildings along Highway 84/285 and the Santa Cruz-Chimayo road appeared to have been built relatively recently, perhaps within the last decade. Ted Galusha, who worked in this area from the 1930's through the 1960's remarked that only one house existe along an earlier version of Highway 84/285 north of Pojoaque about 20 years ago.

A less subjective indication of the recent population growth of this area was obtained by checking population figures for the major settlements and towns since 1940 . These were derived from several editions of the Rand McNally Commercial Marketing Atlas, and do not include a substantial fairly dense rural population outside of the towns. (see Table 10).

TABLE 10 . Growth of major communities in the Espanola area adjacent to the Espanola division of the S.R.G.R.A. The 1978 figure for Espanola comes from a road sign at the city limits.

TOWN	1978	1970	1960	1940
Espanola	8,000	5,900	1,975	645
Santa Cruz		600	450	600
Chimayo-Sanctuario		1,500	900	1,500
San Pedro		200	500	-
TOTAL		8,200	3,825	2,745

The pattern of growth appears to involve an initial expansion along the flat areas on either side of a highway or road, and then a "migration" into the surrounding badlands via arroyos. Evidence of this is particularly conspicuous along highway 84/285 in Arroyo Seco and near the "Three Sisters" (Plate 2, figs. A,C).

Thus far, few of the badlands exposures along highway 84/285 have been affected, but numerous important vertebrate localities are close to (within 1 mile of) this highway, and would be affected by continued development. An indication of a potentially serious impact situation is a line of residences along the dirt road just north of Arroyo Seco (Plate 2, fig. A), between the highway and the first topographically conspicuous badlands to the east. The easternmost of these residences includes a junkyard of at least an acre in extent, and it is a few hundred yards west of the type section for the upper part of the highly fossiliferous Skull Ridge Member of the Santa Fe Group. Across the road are exposures that have yielded camel and carnivore partial skeletons. If building were to continue along this road to the east, these two important localities would be affected almost immediately by the surface disturbances that occur when a residence is being constructed.

A similar situation is present along the Santa Cruz-Chimayo road, which has a fairly high population density already in several places. This road passes across the mouths of several large washes, numbered by A.M.N.H. collectors as "First" Wash, "Second" Wash, etc., and whose drainage areas north of the road contain many A.M.N.H. sites and yielded good fossil vertebrate material to us as well. Buildings are present at the mouths of many arroyos and along their sides in several cases, again within a mile of important vertebrate sites.

Immediately south of the Santa Cruz River are numerous residences, some associated with small farms on the river valley alluvium. White Operation Wash opens into the Santa Cruz River in section 8, T 20 N, R 9 E, and drains an extensive area of badlands lying between the river and Arroyo Seco. Roads criss-cross White Operation Wash near its mouth; a cluster of residences form the small community of La Puebla. Residences are also scattered over the surrounding badlands as many as two miles from the mouth of the wash (see Plate 3, figs. D, E, and F). About 2½ miles from the mouth of White Operation Wash, in the N½ of section 10, T 20 N, R 9 E, is White Operation Quarry and several smaller quarries that yielded numerous well preserved mammal fossils to A.M.N.H. collectors (Plate 2, fig. D). Although the spread of residences has not yet reached this area, a road up the wash and a small earth-fill dam across it (Plate 2, fig. E) testify to a fairly high level of human activity in the area.

Another manifestation of increasing human use of badlands exposures resulting from increased population is present in the NW¼ sec. 13, T 20 N, R 9 E (Cundiyo quadrangle), in the form of a large trash dump and landfill operation, presumably for the town of Chimayo (Plate 3, figs. A, B, and C). The dump appears to have spread in a random fashion in several directions over several acres of Santa Fe exposures, and is associated with a couple of small ponds. It lies just east of Rak's "East Santa

Fe" locality and just south of another area (Sanctuario locality) in the E½ of sec. 12, that produced good vertebrate fossils. These localities are in the fossiliferous upper beds of the Nambe Member, and in fact form part of the type locality for that member.

One factor that appears to have limited development along the Arroyo Seco road and away from the mouth of White Operation Wash is land ownership. The houses present in these areas are on private land; the threatened localities are on public (B.L.M. and State) lands. So far this has restricted direct impact by the builders of houses, but has not restricted the potential indirect impact of having numerous people very close to the fossil localities. We have no way of knowing how many fossils are picked up by casual collectors and taken away. This pressure may be significant in view of the fact that most surface fossil deposits in these areas have probably eroded out since the last A.M.N.H. activity here. Thirteen years have passed during which the increasing number of residents in these areas have had the unhindered opportunity to collect newly exposed fossils.

The dam and trash dump are both on B.L.M. lands, presumably with the acquiescence of the B.L.M. Both impacts are unfortunately very close to areas of demonstrated paleontological and geological importance and probably were initiated without regard to these resources.

How can these impacts on this paleontologically important area be mitigated? Obviously relatively little can be done in the most highly populated areas, because these are on private land. Population growth on private land around Espanola and the Santa Cruz River valley will continue in response to factors over which land managing agencies have little or no control. The B.L.M. can play a much more active role on land under its jurisdiction, which, fortunately, contain the majority of important fossil localities within the Espanola division. We strongly urge that development of any kind on federal land in the areas discussed above be halted, and that any future land use activity be considered very carefully. The nature of the exposures here is such that fossils will continually erode out of some beds, and they can best be preserved by a periodic "harvesting" or collecting program under conditions where the exposures are not disturbed by land use activities. Preservation of the type sections in this area would also be encouraged by allowing the land to return to its natural state. Construction of buildings, dams, dumps and other such features in the future should not be allowed. There seems to us to be no compelling reason for allowing the trash dump on B.L.M. land to continue; large areas of private land containing Precambrian and unfossiliferous units of the Nambe Member exist southeast of Chimayo, where the possibility of severe impact on paleontological resources is negligible. The existing dump should be covered and no further dumping there permitted.

We see little hope of effectively regulating the indirect impacts caused by the increase in population adjacent to these B.L.M. lands. These impacts can be partially offset by the initiation of a program of periodic survey and sampling of the fossils on B.L.M. land, either by B.L.M. paleontologists or others. This should allow most of the fossils that erode from the exposures to be preserved by paleontologists. In addition, as little attention as possible should be drawn to the fossils in this area, as a way of limiting the number of non-paleontologists entering the area to remove fossils. The state of New Mexico should be encouraged to take a similar attitude to land use in lands under State jurisdiction (e.g. sec. 16, 17, 19, 20, 21, 30, T 20 N, R 9 E).

Other Areas of Potential Impact due to Population Growth. The Tierra Amarilla, Cochiti, Hagan, and most of the Ojo Caliente and Santa Fe divisions do not contain nor are close to any towns of over a few hundred people, and the impact of population growth on the paleontological resources is small enough to be ignored for the present. In the Ojo Caliente division, the small towns of Ojo Caliente, Dixon, Embudo and Rinconada are near fossiliferous exposures of the Santa Fe Group, but these towns are all on private land and have not grown much over the past 30 years; population pressure on fossil deposits nearby is slight. In the event that the population of these areas begins to grow rapidly in the future, greater attention will have to be devoted to the adjacent B.L.M. lands, and possibly additional measures taken to preserve the paleontological resources therein. No such action is justified now.

The proximity of the city of Santa Fe to the Santa Fe division means that this division is probably already receiving many visitors; certainly access into most parts of the area is not difficult. Because there are few fossils of any importance in this division, increased numbers of residents or recreational visitors are not of concern.

The southern part of the Bernalillo division receives many visitors because of it's proximity to Albuquerque; the presence of Navajo Canyon Dam, a recreational area; and the presence of New Mexico State highway 44, a major route to the north. Further, a network of dirt roads excavated by the promotors of the Rio Rancho residential development (we presume) exists southwest of Bernalillo and part of this road network extends into the Bernalillo division. The town of Bernalillo is expanding northward along highway 44 and the construction of buildings near the boundary or within the Bernalillo division may be anticipated. Because of these factors, the degree of land use and the number of people passing through this area are significant and would pose a distinct danger to any paleontological resources. However, the locally extensive Santa Fe badlands here are either essentially barren of fossils and/or covered by basaltic debris. Some fossil Pleistocene sloth remains were found outside the B.L.M. land to the west.

Although the presence of significant fossil deposits within the southern part of the Bernalillo division is undocumented at present, the existence of fossils in equivalent strata to the north suggest that major excavations into either the Santa Fe or Pleistocene deposits should be visited by a paleontologist at least once during each excavation. Those doing the excavating should be encouraged to report any fossil discoveries to the B.L.M.

10) Mining. Aside from the quarrying of sand and gravel (discussed earlier), and a few active mines in nonsedimentary rocks, no mining is currently occurring in the S.R.G.R.A. In the past, three coal mines of moderate size operated in the Hagan Basin Coal Field near the now abandoned town of Hagan (see Kelley & Northrop, 1975, for a complete discussion). Coal was mined from seams in the Mesa Verde Formation at the Pino Vetitos, Sloan, and Hagan mines; of which the Hagan mines were most extensive. All were underground mines. The Hagan mines operated from 1903 to 1909 and from 1925 to 1931. Production from the mines was relatively small compared to the estimated reserves, and Kelley & Northrop (1975, p. 113) stated that the

Hagan Basin "certainly has more potential, especially if underground gasification were to become feasible."

Information obtained from the B.L.M. and other sources, and observations made during our field work indicate that some active relatively intensive exploration is being conducted by Union Carbide and perhaps other companies in an area of Galisteo exposures around Arroyo del Tuerto, in the Hagan division. Surface evidence of this exploration is conspicuous, consisting of drill holes and recently excavated roads, which constitute a potentially serious impact on the fossils within the Galisteo here. Detailed information concerning Union Carbide's exploration results, areas of major interest and plans for active mining were unavailable to us, however.

Some of this exploration activity is very close to several vertebrate localities, including the "Stearns quarry" bone bed. If active mining begins, the possibility of serious disturbance of these localities is great - if not from the mining itself, then from associated activities such as road construction.

The Galisteo localities constitute one of the three areas within the S.R.G.R.A. having the greatest paleontological significance. In view of the existing exploration impact, which is apparently unregulated under the 1872 Mining Act; the good possibility of serious disturbance if active mining begins; and the possibility mentioned earlier, of a new segment of interstate highway being constructed in the area, we suggest that the existing vertebrate sites be completely excavated as soon as possible. In addition, any mining activity that extensively disturbs surface exposures of the Galisteo should be monitored either continuously or with a high frequency of visits by paleontologists to the mining area. Extraction of these fossils in an unhurried scientifically impeccable way will only become more difficult as these different types of land use impinge upon the sites. Further, we are concerned that present exploration activity might damage one or more sites; the bones are very brittle and could be fragmented beyond usefulness by relatively slight disturbance. Thus, we believe that these Eocene bones can be preserved best by completely excavating them.

Excavation could involve a relatively substantial quarrying operation, as the main bone bed is steeply dipping, intersects the high side of Arroyo del Tuerto, and is of unknown lateral extent. Excavation would require the removal of much overburden and then a careful extraction of the fragile bones along the entire exposed surface of the bed. We estimate that between 50 and 100 person-days would be required to complete the excavation; less time would be needed if a back-hoe or other earthmoving machine were available.

SUMMARY AND RECOMMENDATIONS

The Southern half of the Rio Grande Resource Area (S.R.G.R.A.) includes seven divisions containing sedimentary rocks of Jurassic to Quaternary age, as well as extensive volcanic and some Precambrian rocks. Most of the sedimentary units contain fossils, and one unit, the Santa Fe Group, contains contains one of the most abundant, diverse and thoroughly collected Tertiary vertebrate faunas in the world. From exposures of this unit alone, in and around the S.R.G.R.A., the A.M.N.H. removed over a 40 year period many thousands of Mio-Pliocene mammal bones and nearly 200 partial or complete skeletons. Santa Fe exposures cover about 50% of the S.R.G.R.A. Relatively little scientific work has been accomplished on the fossils within the other formations. This report summarizes the nature and extent of previous work and collections of fossils from the S.R.G.R.A., documents the present occurrence of fossils in the area, and analyzes the present and potential effects of various land use activities on the paleontological resources.

In most parts of the S.R.G.R.A., land use impact on fossils is relatively minor at present. This assessment results from a combination of: 1) little or no significant land use being present in many of the less accessible and least populated parts, 2) no fossils being present in large areas of the S.R.G.R.A., and 3) the fossils in some units being readily available in large areas outside of the S.R.G.R.A.

We have identified three areas (Figs. 7 and 8) where important paleontological resources are present and which are or soon will experience severe impact from various types of land use activities. These areas are:

1) About 24 sections between Santa Cruz River, Pojoaque Bluffs, the Nambe-Chimayo road (N.M. State highway 4), and the south

boundary of the Espanola division. This area contains extensive Santa Fe badlands in which there are many vertebrate fossil localities and some quarries, and the type sections for two of the most fossiliferous units within the Santa Fe Group, the Skull Ridge and Nambe Members.

2) About 6 sections north of the Santa Cruz River, encompassing "First" through "Third" Washes and their drainage areas, which include badlands exposures formed from the Pojoaque and Skull Ridge Members of the Santa Fe Group. Previous collectors as well as our team recovered important mammalian fossils from this area, and the area also includes the type section for the fossiliferous Pleistocene Espanola Formation.

3) A small area (about 1¼ sections) along the Arroyo del Tuerto, containing Galisteo exposures with several Eocene mammal localities, including a thin bone bed.

The following recommendations are made regarding the paleontological resources of these areas and the S.R.G.R.A. in general.

1. Land use within the two Santa Fe Group areas should be halted and an attempt made to prevent any future land use activities. These areas should be allowed to return to a natural state and should be regarded as paleontological preserves by the B.L.M. The trash dump on B.L.M. land south of Chimayo should be relocated out of the area of concern.
2. The main impact on the two Santa Fe Group areas comes from a rapid increase in the population around Espanola and along the Santa Cruz River, with accompanying increased human use of the adjacent

fossiliferous public lands. If these areas were in poorly accessible regions, fencing and occasional surveillance would be all that would be required to adequately preserve the paleontological resources. However, because these areas are so accessible to large numbers of people, destruction of much paleontological information through the removal of fossils by non-paleontologists is a virtual certainty. We therefore recommend that a program of yearly or bi-yearly sampling be initiated, in order to sample fossils that are continually eroding out of some beds, and to insure that most of the fossils come into the hands of paleontologists rather than others. The sampling program could be conducted by B.L.M. or other qualified paleontologists under contract with the B.L.M. The possibility of discovering additional dense bone concentrations exists, and the means and committment to promptly excavate them should be developed.

3. The Eocene fossil vertebrate localities in the Galisteo Formation around Arroyo del Tuerto should be excavated as soon as possible. A sample should also be taken of the fossil logs in this area. Present surface disturbance by mineral exploration, and potential mining and interstate highway construction in this area place these paleontological resources in some danger. After the excavation of the fossils, land use activities involving excavations of any kind in Galisteo exposures should be continuously monitored by paleontologists. The sporadic distribution of vertebrates in the Galisteo Formation does not justify the prohibition of planned land use activities.

4. An attempt should be made to contact the owners of sand and gravel quarries within the S.R.G.R.A. and encourage them to report fossils uncovered in the quarry operations. To our knowledge no fossils have been found in quarries within the S.R.G.R.A., but occasional discoveries of Pleistocene vertebrates in similar situations elsewhere suggest the possibility of such finds.
5. Any large excavation, such as mining or road construction, in exposures of the Santa Fe Group for which few or no fossils have been reported should nevertheless be monitored by B.L.M. paleontologists. The distribution of fossils in many Santa Fe units is sporadic and localized, and in some cases no surface fossil remains exist to indicate subsurface bone concentrations that might be fortuitously uncovered by excavations.
6. Because our field work was limited in this survey, we can make no first hand statements about the presence or absence of fossils in many locations within the S.R.G.R.A. Therefore, we recommend that local surveys be done by the B.L.M. in all areas of sedimentary rock exposure that become scheduled for land use activities involving significant excavation or other relatively severe surface disturbance.
7. We recommend finally that this survey be continued.

The tremendous quantity of fossil materials collected by the American Museum of Natural History from the Santa Fe Group in the period 1924-1965, and the imprecision of much of the earlier data regarding collections and specific localities, make it imperative that this report be extended by additional analyses and compilation of this type of information. Much detailed information is in the archives of the A.M.N.H., but it is not in a form that will allow easy and direct retrieval. Instead, the data is buried in field notebooks, reports and letters that would require a person intimately familiar with the procedures and yearly collecting activities of the Frick field parties to interpret. The only person still living who was involved in collecting and prospecting efforts in the earlier phases of A.M.N.H. activity on the Santa Fe Group, at a time when locality and stratigraphic data was not always recorded for specific important fossil vertebrate deposits, is Mr. Ted Galusha. Mr. Galusha was involved in fieldwork in and around the S.R.G.R.A. from the 1930's and supervised fossil collecting operations from 1942 until 1965. He would be uniquely able, because of his familiarity with the area and with the collecting activities of long deceased A.M.N.H. and Frick paleontologists, to interpret old records and provide much additional information on many aspects of the paleontological resources of the Santa Fe-Espanola area. Time is critical; Mr. Galusha is 67½ years old. When he dies much information of great importance to the proper managing of Santa Fe Group paleontological resources will be irretrievably lost.

Thus, we recommend that Mr. Galusha be contracted, on a sole-source basis, to assemble from available sources, including his own experience, all extant information on early A.M.N.H./Frick collecting activities, fossil locations, stratigraphic distribution of important fossil horizons and other paleontological data. Further justification and information is presented in Appendix [illegible]. in the form of a proposal that has been submitted to the B.L.M.

ACKNOWLEDGMENTS

We thank the staff of the Department of Vertebrate Paleontology, American Museum of Natural History, New York, for much cooperation, advice and help during our examination of their Santa Fe Group collections, and in the preparation of the Santa Fe faunal lists. We acknowledge especially the help of Dr. Richard Tedford, Beryl Taylor, and Earl Manning, of the Department of Vertebrate Paleontology. We are grateful also to Ted Galusha, Curator Emeritus of the A.M.N.H., for spending several days discussing the Santa Fe Group and its fossil mammals with us. The responsibility for any errors of fact in this report is, of course, ours rather than theirs.

PLATES

PLATE 1

A. West edge of Santa Ana Mesa, showing slopes of Santa Fe Group covered with basalt debris from the flow that caps the mesa. This topography is common in the southern part of the S.R.G.R.A.

B. Jemez Canyon Dam. Construction of this dam uncovered fresh exposures of Santa Fe Group (some are visible on far side of dam). Future land use activities of this kind should be accompanied by paleontological surveys.

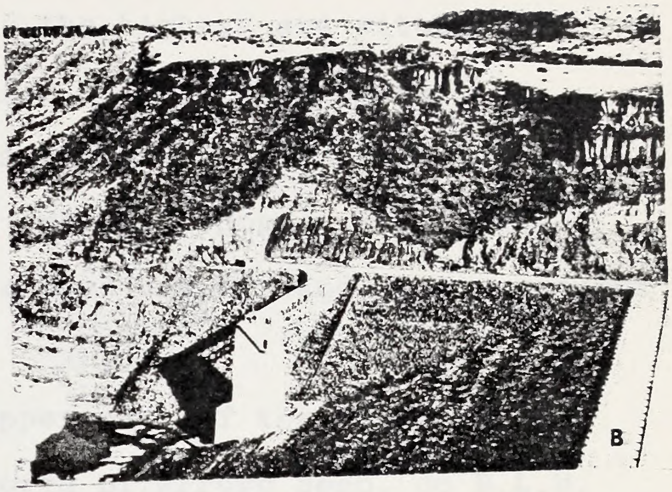
C. Dump along road in the southwestern part of the Bernalillo division of the S.R.G.R.A. This area has numerous dirt roads that occasionally create exposures of the Santa Fe Group, but generally this unit is covered by Quaternary alluvium. Dumps are a form of land use that are often unauthorized by the B.L.M. and are aesthetically displeasing.

D. View of badlands in the Chama-el Rito Member, Tesuque Formation, on the northwest side of the Ojo Caliente River, a few miles north of Espanola. These badlands are quite extensive and yielded many vertebrate fossils to A.M.N.H. collectors, though we found few during our field work in this area.

E. Ridge along divide between drainages of "First" and "Second" Washes. Much vertebrate material was collected in this area by the A.M.N.H., and the exposures shown here produced much for us as well. This area is within one of the paleontological preserves recommended in this report.

F. Part of the type section of the Nambe Member, Tesuque Formation, in the Espanola division of the S.R.G.R.A. These beds have yielded many fossils and represent part of the most continuous section of this member in existence.

A



B

C

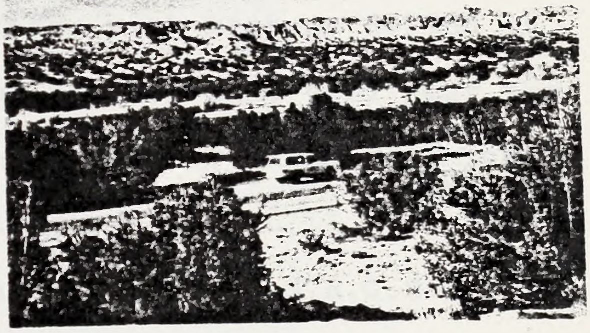


PLATE 2

A. View looking northwest along U.S. Highway 84/285, just south of Arroyo Seco Wash. Residences near the highway are within the Espanola division of the S.R.G.R.A., but are on private land. These structures, which have probably been built within the last decade, illustrate the rapid growth of population in the Espanola area, with resulting increased use of land near exposures of the Santa Fe Group.

B. View of the type section of the upper part of the Skull Ridge Member, Tesuque Formation, just north of Arroyo Seco, on B.L.M. land. Just .2 miles to the right (west) of this picture is the residence/junkyard shown in Figure C.

C. View looking west of residence/junkyard, with highway 84/285 in the background. This structure is on private land very near the type section shown in B, which, with associated exposures, has produced several important vertebrate fossils.

D. White Operation Quarry, in the Espanola division, S.R.G.R.A. Numerous partial skeltons and bones were excavated from this and nearby quarries by the A.M.N.H. in the 1930's. Much bone scrap and some worthwhile fossils (see Plate 4, figs. C & E) are still present in this area.

E. View, looking north, of an earth-fill dam (just beyond truck) across White Operation Wash. In the background are extensive exposures of the Skull Ridge Member, Tesuque Formation, that contain White Operation and other quarries.

A

B

D

C

E

PLATE 3

A. View, looking north, from the Nambe-Chimayo Road just south of Sanctuario, towards badlands of the Nambe Member, Tesuque Formation. The trash dump shown in Figures B and C is barely visible in the left 1/3 of the photo.

B. Part of trash dump/landfill operation southwest of Sanctuario on B.L.M. land.

C. Same as B, showing proximity of dump to good exposures of the Nambe Member. Several good fossil areas are present directly to the north and west of the dump.

D. Residences in White Operation Wash, near where it intersects the Santa Cruz River flood plain. These structures are on private land, but the fossiliferous badlands on the horizon are on B.L.M. land. Expansion of population over the last two decades has brought these badlands areas within close proximity to significant numbers of people.

E. Residences along north side of White Operation Wash.

F. Residences in badlands hills south of the Santa Cruz River near White Operation Wash. With continuing growth in population, use of badlands areas may be expected to increase, with resulting severe direct impacts on fossil deposits within the badlands.

A

B

C

E

PLATE 4

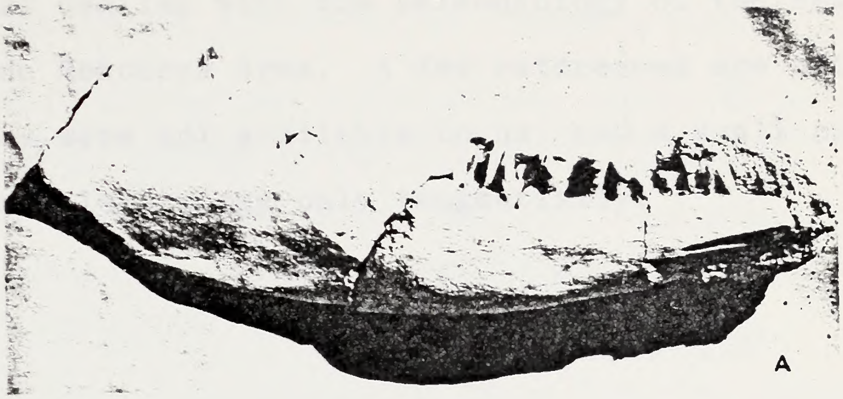
A. Lower jaw of the rhinoceros *Aphelops*?, B-1581, from locality BUNM-78-44, along First Wash. Pojoaque Member, Tesuque Formation.

B. Head of a proboscidean femur, B-1595, from locality BUNM-78-48, along Prince Ranch Wash. Chama-el Rito Member, Tesuque Formation.

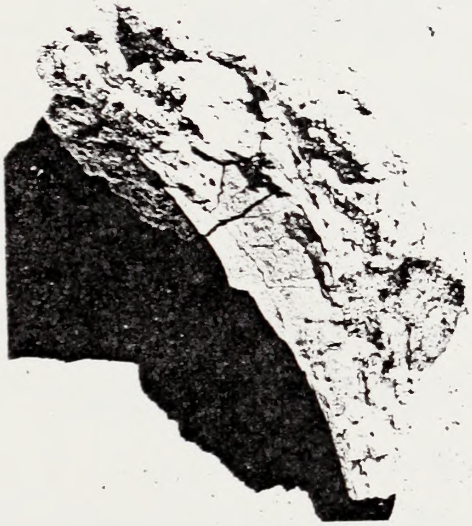
C. Articulated foot elements of a horse, B-1619, from locality BUNM-78-58, near White Operation Quarry. Skull Ridge Member, Tesuque Formation.

D. Lower jaw of a merycodont artiodactyl, B-1552, from locality BUNM-78-37, along "First"Wash. Pojoaque Member, Tesuque Formation.

E. Lower jaw of *Merychippus*?, a Miocene horse, B-1626, from locality BUNM-78-58, near White Operation Quarry, Skull Ridge Member, Tesuque Formation.



A



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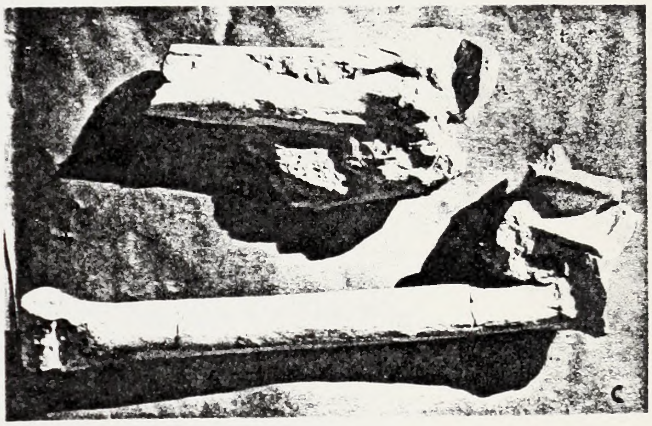

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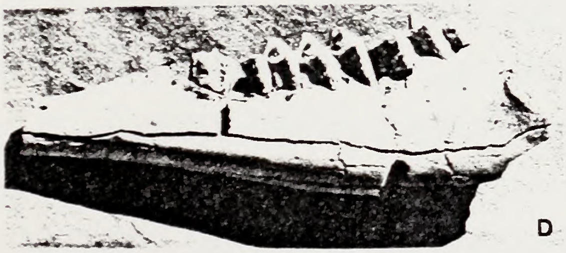

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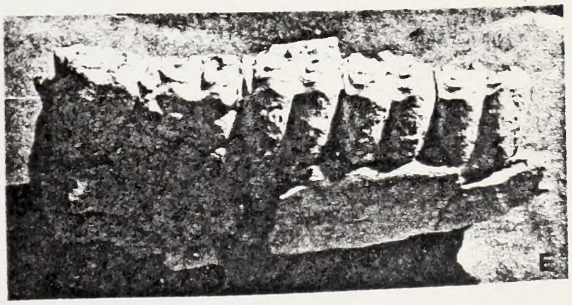

E

ANNOTATED LIST OF REFERENCES

This list of references includes annotated entries for published and unpublished papers dealing with the paleontology of the Southern half of the Rio Grande Resource Area. A few references are not annotated because they were not available to us, and a small number of references concern paleontology only tangentially.

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Baldwin, B. (1956), The Santa Fe Group of north-central New Mexico: Guidebook of southeastern Sangre de Cristo Mountains, New Mexico, 7th Field Conf., N.M.G.S., pp. 115-121.

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Baldwin, Brewster, and Kottlowski, F. E., 1968, Scenic trips to the geologic past, no. 1, Santa Fe: N.M. Inst. Min. and Tech., State Bur. Mines and Mineral Res. Guidebook, 51 p.

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Colbert, E. H., 1941, The ancestral ursid, Hemicyon, in Nebraska: Bull. Univ. Nebr. State Mus., vol. 2, pp. 49-57

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Colbert, E. H., and Northrop, S. A., 1950, Guidebook for the fourth field conference of the Society of Vertebrate Paleontology in northwestern New Mexico, 91 p.

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Cope, E. D., 1875e, On an extinct vulturine bird: Acad. Nat. Sci. Phila. Proc. 1875, p. 271.

Describes the skeleton of *Cathartes umbrosus*, not a "true vulture".

Cope, E. D., 1875f, The Wheeler geological survey of New Mexico for 1874: Am. Nat., v. 9, p. 49-52.

Describes the itinerary of the survey while in New Mexico. Beds in the valley of the Rio Grande are attributed to lake deposits and a brief outline of the extinct biota is given.

Cope, E. D., 1875g, A new mastodon: Am. Nat., v. 9, p. 56.

Mastodon productus demonstrates the Pliocene age of the Santa Fe Beds.

Cope, E. D., 1876a), On the antelope deer of the Santa Fe marls: Acad. Nat. Sci. Phila. Proc. 1875, p. 257.

Reports the following species from the Santa Fe: *Dicrocerus necatus*, *D. furcatus*, *D. gemmifer*, and D. *teres*. The Santa Fe fauna more closely resembles the upper Miocene of Europe than the Pliocene.

Cope, E. D., 1 77, Report upon the extinct vertebrata obtained in New Mexico ...: U.S. Geog. Surveys west of the 100th meridian Wheeler , v. 4, pt. 2, 371 p.

A lithologic description of the "Loup Fork Beds" is given as well as a complete review of Cope's collection from these beds amply illustrated.

Cope, E. D., 1882, The Tertiary formations of the central region of the United States: Am. Nat., v. 16, p. 177-195.

The Santa Fe "marls" identified by Cope as "Loup Fork" in age. A brief lithologic description is also given.

Cope, E. D., 1884b, On the distribution of the Loup Fork formation in New Mexico: Am. Philos. Soc. Proc., v. 21, p. 308-309.

Extends the distribution of the "Loup Fork" (= Santa Fe Group) far south of Socorro and into the Gila River. Age of the beds is clear from the occurrence of *Aphelops fossiger*.

Cope, E. D., 1884c, On extinct rhinoceri from the Southwest: Acad. Nat. Sci. Phila. Proc. 1883, p. 301.

Aphelops fossiger from the "Loup Fork Bed of the valley of the San Francisco River, New Mexico".

Cope, E. D., 1884d, The Loup Fork beds on the Gila River: Am. Nat., v. 18, p. 58-59.

Description of the geology of theSanta Fe Group along the Gila River and report of a skull of *Aphelops fossiger* found in these beds.

Dane, C. H., 1960, "The Dakota Sandstone and Mancos Shale of the Eastern side of San Juan Basin, New Mexico": N.M. Geol. Soc., 11th Field Conf. Guidebook, p. 63-74.

Detailed discussion of stratigraphy and mention of characteristic fossils from Tierra Amarilla Grant and southward, including units and localities within the S.R.G.R.A.

Dane, C. H. and G. O. Bachman, 1965, Geologic map of New Mexico: U.S.G.S. map G. 63272.

Shows distribution of rock-stratigraphic units throughout the state.

Dane, C. H., W. A. Cobban and E. G. Kauffman, 1966, Stratigraphy and regional relationships of a reference section for the Juana Lopez Member, Mancos Shale, in the San Juan Basin, New Mexico; U.S. Geol. Surv. Bull. 1224-H; 15 pp.

Includes a formal list for this member, which crops out in many places in north-central New Mexico, including the Tierra Amarilla area of the Southern Rio Grande Resource Area.

Davis, W. M., 1900, The freshwater Tertiary formations of the Rocky Mountain region: Proc. Amer. Acad. Arts and Sci., vol. 35, pp. 345-373.

Dawson, M. R., 1958, Later Tertiary Leporidae of North America: Univ. Kansas Paleont. Contrib. Vertebrata, art. 6, pp. 1-75.

Panolax sanctaefidei Cope redescribed with measurements but unfortunately not illustrated.

Dawson, M. R., 1967, Lagomorph history and the stratigraphic record: Univ. Kansas Dept. Geol. Special Publ. 2, pp. 287-316.

Panolax sanctaefidei Cope included in a list of the stratigraphic record of fossil rabbits and tentatively assigned a Clarendonian age.

Denny, C. S., 1938, Santa Fe Formation [abs.] : GSA Bull., vol. 49, p. 1877.

Brief summary of the geology of the type area of the Santa Fe, including: location and extent of type area, depositional systems ("...coalescing alluvial fans in a basin..."), sources of sediment, and post-Santa Fe deformation.

Denny, C. S., 1940, The Santa Fe Formation in the Espanola Valley, New Mexico: GSA Bull., vol. 51, pp. 677-694.

A complete geologic description of the type area of the Santa Fe Formation including lithology of sediments, structural geology, origin of deposits ("an alluvial fan deposit") their thickness and distribution (original and present), and discussion of climate during Santa Fe time.

Disbrow, A. E., and Stoll, W. C., 1957, Geology of the Cerrillos area, Santa Fe County, New Mexico: N. Mex. Inst. Min. Tech., State Bur. Mines and Mineral Res. Bull. 48, 73 p.

Discusses local stratigraphy and general geology of part of S.R.G.R.A.

Doney, H. H., 1968, Geology of the Cebolla Quadrangle, Rio Arriba County, New Mexico"; N. M. Bur. Mines and Min. Res. Bull. 92, 114 p.

Detailed stratigraphic descriptions, along with mention of important fossils in Cretaceous rocks just NE of Tierra Amarilla part of S.R.G.R.A.: the same units and faunas extend into this BLM area.

Frick, C., 1926, Prehistoric evidence: Nat. History, v. 26, #5, p. 440-448.

Brief description of the Santa Fe group sediments and history of collecting description of some of Frick's early collecting experiences in New Mexico.

Frick, C., 1926a, The Hemicyoninae and an American Tertiary bear: AMNH Bull., v. 56, p. 1-119.

Description of the neotype skull and skeleton of *Hemicyon* (*Canis*) *ursinus* from the "Santa Fe Miocene" of New Mexico. Classification and description of other hemicyonine carnivores as well as description of a new genus of bear *Plionarctos*.

Frick, C., 1926b, Tooth sequence in certain trilophodont tetrabelodont mastodons and *Trilophodon* (*Serridentinus*) *pojoaquensis*, n.sp.: AMNH Bull., v. 56, p. 123-178.

Trilophodon productus and *T. pojoaquenis* n.sp. described and illustrated. These and other taxa used to elucidate tooth sequences and their bearing on elephant evolution.

Frick, C., 1977, New remains of trilophodont-tetrabelodont mastodons: AMNH Bull., v. 59, p. 505-652.

Descriptions and illustrations of the following longirastrine elephants from the Santa Fe Group: *Serridentinus productus*, (?) *Serridentinus pojoaquensis*, *Trilophodon cruziensis* n.sp., *Ocalientinus ojocaliensis*

n. gen. et. sp., Trobelodon taoensis n. gen. et. sp., Tatabelodon riograndensis n. gen. et. sp., (?) Amebelodon joroki n. sp.. Mastodon raki n. sp. named from the Pleistocene of New Mexico.

Frick, C., 1937, Horned ruminants of North America: AMNH Bull., v. 69, 669 p.

An exhaustive and exhausting revision of a major part of the North American Artiodactyla. The following from the Santa Fe Group are included: Ramoceras ramosus, Meryceros (submeryceros) crucianus, Cranioceras teres, (?) Longirastromeryx blicki, Blastomeryx francesea, Blastomeryx francescita, Ramoceras ramosus quadratus, Ramoceros (Paramoceros) marthae, Ramoceros (Paramoceros) paimatus, Cosoryx (subcosoryx) cerroensis, Cosoryx ilfonsensis, Meryceros major, Meryceras crucensis, Osbornoceros osborni, Plioceras blicki, Pseudoceras Klausi, Rakomylus raki.

Frick, C., and B. Taylor, 1968, A generic review of the stenomyline camels: AMNH Novitates, #2353, 51 pp.

Revision of this aberrant subfamily of camels includes Blickomylus galushai n. gen. et. sp. from the Zia Sand, and Rakomylus raki from "the lower part of the Santa Fe Group". Stenomylus (Stenomylus gracilis from the Zia Sand is also discussed.

Frick, C. and B. Taylor, 1971, Michenia, a new Protalabine (Mammalia, Camelidae) and a brief review of the early taxonomic history of the genus Protolabis: AMNH Novitates, #2444, 24 pp.

Cope's Procamelus occidentalis from the Santa Fe Group referred to Protolabis.

Galusha, Ted, 1966, The Zia Sand Formation, new early to medial Miocene beds in New Mexico: Amer. Mus. Novitates, n. 2271, 12 p.

Original description and definition of the Zia Sand Formation (Early-Mid Miocene) and designation of the type area - near San Ysidro, N.M. A map is included of the area, and a brief mention of the vertebrate fauna.

Galusha, T., 1974, Dating rocks of the Santa Fe Group: programs and problems: NMGS Guidebook 25th Field Conf., pp. 283-286.

Geochronologic problems of theSanta Fe Group are outlined and tentative correlations are presented. A faunal list to familial level of vertebrate taxa of the Santa Fe Group is given.

Galusha, T. and J. C. Blick, 1971, Stratigraphy of the Santa Fe Group, New Mexico: AMNH Bull., vol. 144, pp. 1-128.

Geology of the Santa Fe Group and adjacent units in the Rio Grande Valley and selected adjoining areas between the Sangre de Cristo and Jemez Mountains. The following rock stratigraphic units are named: Nambe Member, Skull Ridge Member, Pojoaque Member, Chama-el Rito Member, Ojo Caliente Sandstone (all in the Tesuque Formation); Chamita Formation, Espanola Formation. Faunal lists of fossil vertebrates and age and correlation of the Santa Fe Group are included. A very important paper.

Gawne, C. E., 1975, Rodents from the Zia Sand Miocene of New Mexico: AMNH Novitates #2586, 25 pp.

Description of the rodent fauna of the Zia Sand includes the following taxa: Proheteromys cejanus n. sp., P. aff floridanus and Ziamys tedfordi n. gen. et. sp. from the Standing Rock local fauna of earliest Hemingfordian to latest Arikareean age. The Blick local fauna of medial Hemingfordian age includes rodents resembling but not identical to Pleurolicus sulcifrons, Proheteromys and Mookomys. Mesogalus aff. vetus is identified from the Jeep local fauna and is indicative of a late medial Hemingfordian age.

Gawne, C. E., 1976, Lagomorphs from the Zia Sand Miocene of New Mexico: AMNH Novitates #2608, 15 pp.

The Zia Sand contains the following rabbits: Archaeolagus cf. macrocephalus of the Standing Rock local fauna; Archaeolagus sp. and oreolagus cf. nebrascensis from the Blcik local fauna.

Goolsby, R. S., 1965, Geology of the Lamy-Canoncito area, Santa Fe County, New Mexico: UNM M.S. thesis, 68 pp.

Description of the stratigraphy of Precambrian through Santa Fe Formation. Brachiopods were noted in the Madera Fm, Ostrea and Gryphaea were found in the Mancos Sh, Inoceramus labiatus collected from Greenhorn Limestone (?). No localities are given. The area extends north from Lamy to Canoncito.

Gregg, Josiah, 1844, Commerce of the Prairies (The journal of a Santa Fe trader): Dallas, Texas, Southwest Press; 1st ed. 1844; reprinted 1933.

First mention (Kelley and Northrop, 1975, p. 66) of silicified wood in the Galisteo near Cerrillos.

Hall, E. R., 1930, Three new genera of Mustelidae from the later Tertiary of North America: J. Mammal., vol. 11, pp. 146-155.

Martinogale nambiana replaces Cope's *Martes nambianus*. A brief description but no illustrations.

Harrington, E. R., 1939, Forests turned to stone: N. Mex. Mag., v. 17, #4, p. 16-17.

A brief account with photographs of the fossil logs in the Galisteo Formation on Sweets Ranch near Los Cerrillos, New Mexico.

Hay, O. P., 1908, The fossil turtles of North America: Carneg. Instit. Wash. Pub. 75, 568 p.

Description and illustration of Cope's two turtle taxa from the Santa Fe Group: *Testudo undata* and *T. klettiana*.

Hayden, F. V. 1869, Preliminary field report of the United States Geological Survey of Colorado and New Mexico. Wash.: U. S. Gov't. Printing Office, 155 pp.

Naming of the Santa Fe "marls" and Galisteo sandstone. Mentions fossil logs in the Galisteo.

Herrick, C. L., 1898, The geology of the environs of Albuquerque, New Mexico: Amer. Geol., vol. 22, pp. 26-43.

Herrick, C. L. and Johnson, D. W., 1900, The geology of the Albuquerque Sheet: Bull. Univ. New Mexico, Hadley Lab, vol. 2, pp. 1-67.

Hirschfeld, S. E. and S. D. Webb, 1968, Plio-Pleistocene megalonychid sloths of North America: Florida State Mus. Bull., v. 12, pp. 213-296.

? *Pliometanastes galushai* n. sp. from the Chamita Formation is illustrated and described. Another specimen of *Pliometanastes*, a braincase of an undetermined species, from the Chamita Formation is discussed.

Hoge, H. P., 1972, Neogene stratigraphy of the Santa Ana area Sandoval County, New Mexico: Ph.D. Dissertation, Univ. New Mexico, 193 p.

Summarizes stratigraphy and general geology of part of the S.R.G.R.A.

Howard, A. D., 1932, The lithology of selected fossiliferous Tertiary sediments: AMNH Novitates #544, pp. 1-24.

Petrographic/mineralogic study of three samples of sediment from the Santa Fe Group. Evidence for eolian and alluvial deposition is detected.

Johnson, D. W., 1902, The geology of the Cerrillos Hills, N.M. School of Mines Quart., v. 24, p. 173-246, 303-350, 456-500.

One of the earliest works on the area, and a very thorough one, including history of work, detailed stratigraphy from "Jura-Trias redbeds" Chinle to "Santa Fe Marls", igneous petrology and petrography of the Cerrillos Hills rocks, economic geology Cerrillos Coal Field , paleontology invertebrate of the Mancos, and plants of the Mesa-Verde Galisteo The area includes the Cerrillos Hills south to Madrid, west to the Galisteo Monocline and north to Bonanza Hill.

Kelley, V. C. and S. A. Northrop, 1975, "Geology of Sandia Mountains and vicinity, New Mexico"; N. M. Bur. Mines and Mineral Res., Mem. 29, 136 pp.

Includes extensive lists of fossils from the sedimentary rocks in this area, including the Galisteo, Mancos and Mesa Verde Formations in the Hagan area.

Keyes, C. R., 1907, Tertiary terranes of New Mexico: Proc. Iowa Acad. Sci., vol. 14, pp. 223-228.

Describes the Tertiary stratigraphy of New Mexico.

Landis, E. R., C. H. Dane, and W. A. Cobban, 1974, "Cretaceous rocks of the Tierra Amarilla Coal Field and adjacent areas, Rio Arriba County, New Mexico", N. M. Geol. Soc. 25th Field Conf. Guidebook, p. 231-238.

Descriptions of stratigraphy lithology and paleontology of Cretaceous formations (Dakota through Lewis Shale) outcropping in an area SE of the town of Tierra Amarilla.

Lee, W. T. and Knowlton, T. H., 1917, Geology and paleontology of Raton Mesa and other regions of Colorado and New Mexico: USGS Prof. Paper 101, pp. 198-217.

Briefly mentions fossil logs and poorly preserved fossil leaves from the "Eocene" Galisteo Formation; also discusses in detail the Hagan Coal field and mentions fossil plants and invertebrates from various Mancos and Mesa Verde beds.

Leidy, J., 1873, Remarks on mastodon from New Mexico: Acad. Nat. Sci. Phila. Proc. 1872, p. 142.

Part of a lower jaw of a mastodon sent to Leidy from New Mexico is described and tentatively identified as a "species resembling *Mastodon angustidens*.

Lesquereuz, Leo., 1872, An enumeration with descriptions of some Tertiary Fossil plants from specimens procured in the 4 explorations of Dr. F. V. Hayden in 1870, USGS Terr., Ann Rept. 5, suppl., 22 p.

Lookingbill, J. L., 1953, Stratigraphy and structure of the Gallina uplift, Rio Arriba Co., N.M., N.M. Univ., M.S. thesis, 118 pp.

Descriptions of the Penn.-Cret. rocks (w/measured sections), structure and economic geology of the area around the confluence of the Rio Gallina and the Rio Chama, with a geologic map near El Vado Reservoir Fossils were collected from the Madera Formation and identified (not listed here). *Ostrea lugubris* and *Gryphaea* were collected from the Carlisle Mbr of the Mancos. *Inocerams* and *Haploscapha grandis* were collected from the upper main body of the Mancos. No localities are given, but the stratigraphic positions are given w/the measured sections.

MacFadden, B. J., 1975, Magnetic stratigraphy of the type Chamita Formation (Hemphillian) of north central New Mexico abs. : GSA Abs. w/programs, v. 7, p. 1182.

Summarizes radiometric and magnetic ages of late Hemphillian mammalian fossils. Also, mentions stratigraphic positions of the San Juan and Rak Camel Quarries, in the Chamita Formation just outside of the S.R.G.R.A.

MacFadden, B. J., 1977, Magnetic polarity stratigraphy of the Chamita Formation stratotype (Mio-Pliocene) and North Central New Mexico: Amer. J. Sci., vol. 277, pp. 769-800.

Summarizes radiometric and magnetic ages of late Hemphillian mammalian fossils. The Hemphillian is correlated with late Epoch 5 and early Gilbert time. Also includes a comprehensive discussion of the Chamita vertebrate fauna.

MacFadden, B. J. and K. Manley, 1976, Magnetic stratigraphy, tephrochronology, and mammalian biostratigraphy of the type Chamita Formation, North-central New Mexico: GSA Abs. w/programs, v. 8, p. 605.

On the basis of mammalian biostratigraphy and fission-track dates the type Chamita Formation is correlated with the geomagnetic-polarity time-scale. The Chamita contains six magnetozones from middle Epoch 5 to early Gilbert time.

Matthew, W. D., 1899, A provisional classification of the freshwater Tertiary of the west: AMNH Bull., vol. 12, pp. 19-75.

Faunal list of the "Loup Fork" age vertebrate fossils from the "Santa Fe Basin".

Matthew, W. D., 1909, Faunal lists of Tertiary Mammalia of the West; USGS Bull. 361, p. 91-120.

A bibliography of Tertiary vertebrate horizons of the West and their correlation, including a general geologic and climatic history of western regions during the Tertiary and development of the "faunal phases" of the Tertiary.

Vertebrates listed for the "Santa Fe Marls" include = *Aelurodon whaelerianus* Cope, ? *Dinocyon ursinus* Cope, *Putorius nambianus* Cope, *Hesperomys* (= *Perornyscus*) *loxodon* Cope, *Panolax sanctaefidei* Cope, *Trilophodon* (= *Gomphotherium*) *productus* Cope, ? *Aphelops jemezanus* Cope, *Merychippus calamarius* Cope, *Neohipparion calamarium* Cope, *Procamelus gracilis* Leidy, *Pliauchenia humphreysiana* Cope, *Palaeomeryx trilateralis* Cope, ? *Merycodus tehuanus* Cope.

Matthew, W. D., 1932, A review of the rhinoceroses with a description of *Aphelops* material from the Pliocene of Texas: Univ. Cal. Publ. Geol. Sci., vol. 20, pp. 411-480.

Aphelops jemezanus listed and briefly redistributed as the only rhinoceros from the "upper Miocene" of the Santa Fe Group, New Mexico.

McPeek, L. A., 1965, Dakota-Niobrara (Cretaceous) stratigraphy and regional relationships, El Vado area, Rio Arriba County, New Mexico: Mountain Geologist, v. 2, p. 23-34.

Meek, F. B., 1970, A preliminary list of fossils collected by Dr. Hayden in Colorado, New Mexico, and California with brief descriptions of a few of the new species: Am. Plilos. Soc. Proc., v. 11, p. 425-431.

Merrill, G. P., 1907, Catalogue of the type and figured specimens of fossils, minerals, rocks, and ores in the Department of Geology, United States National Museum, part 2, fossil vertebrates, fossil plants, minerals, rocks, and ores: U. S. Natl. Mus. Bull. 53, pt. 2, 370 p.

Muehlberger, W. R., 1967, "Geology of Chama Quadrangle, New Mexico", N. M. Bur. Mines and Min. Res. Bull. 89, 114 p.

Detailed stratigraphic descriptions and mention of important fossils in Mesozoic rocks just N of Tierra Amarilla part of S.R.G.R.A.; units and faunas extend into this B.L.M. area.

Murphey, L. V., 1940, A bibliographic index of fossils from New Mexico which have been described and/or illustrated in the geologic literature: Univ. New Mexico, M.S. thesis,

A bibliography, taxonomically and alphabetically arranged, of references to fossils collected in New Mexico prior to 1940 including localities and a synomomy for each listing.

Newberry, J. S., 1876, Report of the exploring expedition...of J. N. Macomb..." Wash., Engineer Dept., U.S. Army, pp. 9-118.

Northrop, S. A., 1962, New Mexico's fossil record: N. Mex. Quarterly, v. 32, 75 pp.

Summarizes the history of collecting, general aspect of the fauna, and general geology and age of the fauna of the Santa Fe Group. Mention is made of the fossil logs in the Galisteo Formation.

Northrop, S. A. and T. L. Popejoy, 1931, Going places and seeing things: N. M. Alumnus, v. 4, #9, p. 10-12.

Fossil "forest" in the Galisteo Formation on Sweets Ranch near Los Cerrillos, N. M. is described. Several photographs of the larger logs and instructions on how to visit the locality are given.

Osborn, H. F., 1909, Cenozoic mammal horizons of western North America, with faunal lists of the Tertiary Mammalia of the west: U.S.G.S. Bull. 361, 138 p.

The Santa Fe "marls" assigned to the Upper Miocene *Protohippus* zone. A faunal list of all vertebrate taxa is given by Matthew.

Osborn, H. F., 1918, Equidae of Oligocene, Miocene, and Pliocene of North America, iconographic type revision: Mem. AMNH, vol. 2, pp. 1-330.

Merychippus calamarius (Cope) figured and described from the Santa Fe *"marls" of New Mexico.* Taken to represent the *Procamelus-M. calamarius* zone of the late upper Miocene.

Osborn, H. F., 1936, Proboscidea, a monograph of .... elephants of the world: N. Y.: AMNH Press, 680 pp.

Complete and confused revision of the elephants including description of the following new taxa from the Santa Fe Group of New Mexico: *Trilophodon pojoaquensis*, n. sp.; *Serridentinus productus* (Cope), new combination; *Megabelodon cruziensis* (Frick), new combination; *Trilophodon (Tatabelodon) riograndersis* (Frick), new combination, *Megabelodon joraki* (Frick), new combination.

Reeside, J. B., Jr., 1927, "The cephalopods of the Eagle Sandstone and related formations in the Western Interior of the Untied States"; U.S. Geol. Surv. Prof. Paper 151, 40 pp.

Lists and describes all ammonoid species known from several Cretaceous Mesaverde localities in northern New Mexico, including the Hagan Coal Field. Illustrated specimens from Hagan area are: *Scaplites leeii* var. *parvis* and *Placenticeras sancarlosense*.

Robinson, P., 1957, Age of the Galisteo Formation, Santa Fe County, New Mexico: AAPG Bull., vol. 41, pp. 757.

On the basis of one *Coryphodon* molar found near Los Cerrillos the lower part of the Galisteo is assigned an early Eocene (Wasatchian) age.

Robinson, P., 1972, Tertiary history, in Geologic atlas of the Rocky Mountain region: Rocky Mt. Assoc. Geologists, p. 233-242.

Correlates Tertiary units of S.R.G.R.A. with those of other Rocky Mt. basins.

Schultz, C. B. and C. H. Falkenbach, 1940, Merycochoerinae, a new subfamily of oreodonts: AMNH Bull; ,vol. 77, pp. 213-306.

Definition of the subfamily Merycochoerinae based on the two genera *Brachycrus* and *Merycochoerus*. *Brachyrus* sp. reported from the "lower part of the Santa Fe Beds east of Espanola" based on five mandibular rami.

Schultz, C. B. and C. H. Falkenbach, 1941, Ticholeptinae, a new subbamily of oreodonts: AMNH Bull., vol. 79, pp. 1-105.

Revision of this subfamily of oreodonts includes the following taxa from the Santa Fe Group: *Ustatochoerus californicus raki*, *U. profectus espanolensis*, *U. skinneri santacruzensis*, *U. medius novomexicanus*.

Schultz, C. B. and C. H. Falkenbach, 1947, Merychyinae, a subfamily of oreodonts: AMNH Bull., vol. 88, pp. 159-286.

Merychyus (*Metoreodon*) sp. indet. reported from the lower part (Miocene) of the Santa Fe Group. Described but not illustrated.

Schultz, C. B. and C. H. Falkenbach, 1968, The phylogeny of the oreodonts: AMNH Bull., vol. 139, pp. 1-498.

The final volume of this long study of the oreodonts includes *Brachycrus vaughni rioosoensis* and *B. rusticus riograndensis* from the Santa Fe Group.

Siems, P. L., 1964, Correlation of Tertiary strata in mountain basins, southern Colorado and northern New Mexico: Mountain Geol., vol. 1, pp. 161-180.

Summarizes the literature on age determinations of the Galisteo Formation and Santa Fe Group. The Santa Fe Group is Miocene to Pliocene in age (Barstovian to Hemphillian) and the Galisteo Formation is Eocene in age (Wasatchian to Duchesnean).

Simpson, G. G., 1925, Reconnaissance of part of the Santa Fe formation [abs.] : GSA Bull., v. 36, p. 230.

Fossiliferous beds of the Santa Fe are stream channel and floodplain deposits. The upper part of the formation is more fossiliferous and has some eolian beds as well.

Simpson, G. G., 1950, Cenozoic formations and vertebrate faunas: In Guidebook for 4th Conf. Soc. Vert. Paleo., p. 74-85.

Summarizes the history of study, geology, and vertebrate fauna of the Santa Fe Group. A generic faunal list is included.

Smith, C. T., A. J. Budding, and C. W. Pitrat, 1961, "Geology of the southeastern part of the Chama Basin"; N. M. Bur. Mines and Min. Res. Bull. 75; 57 pp.

Includes stratigraphic descriptions and some paleontological information on units exposed in Tierra Amarilla part of S.R.G.R.A. Also includes geologic maps of these areas.

Spiegel, Z. and B. Baldwin, 1963, Geology and water resources of the Santa Fe area, New Mexico: U.S.G.S. Water-Supply Paper 1525, 258 pp.

The extreme NW corner of this area may reach the study area. The area stops 2 mi south of Tesuque, N.M. included are brief descriptions of all of the rocks (PC to Pleist) in the area, the structure, physiography, drainage, climate, vegetation, population, economic geology, and water resources. Correlations within the Santa Fe Group are attempted, and the origin and age of the Santa Fe are discussed.

[the Santa Fe Group is considered to be mid. Mio-Pleistocene (?) in age - and the nomenclature and extent of "Santa Fe" formation is discussed.]

Stearns, C. E., 1942, A fossil marmot from New Mexico and its climatic significance: Am. Jour. Sci., v. 240, p. 867-878.

A small collection of fossils, excavated from a "dust pocket" beneath the basalt cap of "New La Bajada Hill" during 1940-41 are identified = *Marmota flaviuentris obscura* (marmot), *Thomomys* sp., *Peromyscus* sp. *Bison cf*. *bison*, squirrel, bird, *Celtis* sp. (endocarp).

The presence of the Marmot at such a low altitude indicates a lowering of life zones during the Wisconsin glaciation (the fossils are from the road cut of Hwy. 85).

Stearns, C. E., 1943, The Galisteo Formation of north-central New Mexico: J. Geol., vol. 51, pp. 301-319.

Fossil vertebrates from the upper Galisteo collected by T. E. White are identified as *Uintacyon* sp. and *Teleodus* sp. The Galisto assigned a Duchesnean (late Eocene) age.

Stearns, C. E., 1953a, "Upper Cretaceous rocks of Galisteo-Tongue area, north-central New Mexico, Amer. Assoc. Petrol. Geol. Bull. v. 37; p. 961-974.

Stratigraphy and historical geology of Galisteo-Tongue area, including area around Hagan. Includes a list of Upper Cretaceous fossils and localities.

Stearns, C. E., 1953b, "Tertiary geology of the Galisteo-Tongue area, New Mexico", Geol. Soc. Amer. Bull. 64, p. 459-507.

(Map showing USGS fossil localities on pl. 1.) Structural and historical geology of Tertiary units in Galisteo-Tongue area, part of which includes S.R.G.R.A. lands. A geologic map showing U.S.G.S. fossil localities is Pl. 1 of this article.

Stirton, R. A., 1935, A review of the Tertiary beavers: Univ. Calif. Publ. Geol. Sci., vol. 23, pp. 391-458.

Monosaulax pansus replaces *Steneofiber pansus* named by Cope (1974) and is described and illustrated. Evidently from the "lower beds" of the Santa Fe, Late Miocene in age.

Stirton, R. A., 1936, Succession of North American continental Pliocene mammalian faunas: Amer. J. Sci., vol. 32, pp. 161-206.

The upper Santa Fe considered to be Lower Pliocene in age. A faunal list and selected bibliography is included.

Stirton, R. A., 1940, Phylogeny of North American Equidae: Univ. Calif. Pub. Geol. Sci., v. 25, pp. 165-198.

Merychippus (*M.*) *calamarius calamarius* from the lower Santa Fe Group of New Mexico a valid taxon. *Neohipparion sanfondensis* and *N. Sanjuanensis* both named by Frick (1933) from the Upper Santa Fe Group are *nomina nuda*.

Taylor, B. E. and S. D. Webb, 1976, Miocene Leptomerycidae (Artiodactyla, Ruminantia) and their relationships: AMNH Novitates, #2596, 22 pp.

Revision of this family includes replacement of Frick's *Blastomeryx francescita* with *Pseudoblastomeryx francescita*. This species is described and illustrated.

Thorpe, M. R., 1937, The Merycoidodontidae an extinct group of ruminant mammals: Mem. Peabody Mus. Nat. Hist., vol. 3, pp. 1-309.

Complete revision of the merycoidodonts includes illustration and description of two New Mexican forms: *Metoreodon novomexicanus* from near Santa Cruz, N.M. and *M. medius* from "near Santa Fe".

Vanderhoot, V. L. and J. T. Gregory, 1940, A review of the genus *Aelurodon*: Univ. Calif. Publ. Geol. Sci., v. 25, pp. 143-163.

Aelurodon wheelerianus Cope from the Santa Fe Group of New Mexico may not be a valid taxon, pending further topotypes. *Hemicyon ursinus* distinguished from *Aelurodon*.

Walters, B., 1969, The camels were here: N. Mex. Mag., v. 47, #3, p. 6-7.

Discusses camel tracks fround near Santa Fe and the Bureau of Land Management's efforts to preserve the tracks.

Williams, E., 1950, *Testudo cubensis* and the evolution of Western Hemisphere tortoises: Bull. AMNH, vol. 95, pp. 1-36.

Testudo undata and *T. kletticina*, both named by Cope from the Santa Fe Group are listed as indeterminate forms.

Wood, A. E., 1936, The cricetid rodents described by Leidy and Cope from the Tertiary of North America: AMNH Novitates, #822, 8 p.

Copemys loxodon, new genus and species of cricetid rodent is named, described and figured. The new name replaces "Eumys loxodon" described by Cope in 1874 from the "Santa Fe Beds" of New Mexico.

Woods, Betty, 1947, "Trees of Stone", N. M. Magazine, v. 25, no. 4, p. 13-14, 51-52.

Popular account of petrified trees in Galisteo Fm near Cerrillos.

APPENDIX 1.

MUSEUM
University of Colorado at Boulder
Boulder, Colorado 80309 U.S.A.

23 August 1978

Dr. Barry S. Kues
Department of Geology
University of New Mexico
Albuquerque, New Mexico 87131

Dear Dr. Kues:

The only fossils that we have from the Galisteo Formation are two species of titanotheres, one large and one small, from the quarry at the Arroyo del Tuerto. These were collected by me in 1965 and have never been properly prepared due to the extreme fragmentation of the material. This is the same locality photographed by Stearns in the early 1940's.

Yours truly,

Peter Robinson
Director

PR:lb

APPENDIX 2.

Notes from E. D. Cope's original notebook of the 1874 expedition to New Mexico, regarding fossils collected from the Santa Fe Group. These notes were copied by Ted Galusha from Cope's original notebooks in the American Museum of Natural History.

NOTES FROM E. D. COPE'S ORIGINAL NOTEBOOK OF THE
1874 EXPEDITION TO NEW MEXICO

(These notes were copied by Ted Galusha from Cope's original notebooks in the American Museum of Natural History Jan. 12, 1948. Only notes pertaining to the Santa Fe formation were transcribed.) Page numbers refer to page in Cope's notebook.

Page 20 and 21
8-12-1874 Camp on Rio Grande opposite Santa Clara.

8-13-1874 San Ildefonso and beyond through the Pliocene badlands to the N.west. They form mesas with precipitous faces SE and gentle slope covered with pine on NW side. There a precipices bound long parallel vallies which run NE and SW. In some places the sandstone has a vertical cleavage into quadrate prisms which have a remarkable appearance on the summits of the mesas. At other points they are filled with pieces of pumice which are disintegrated by wind and the dust works out many holes so as to resemble a pigeon box.

Page 22 Map-west side of Rio Grande from Santa Clara Creek to Otowi flow.

Page 23. Pliocene are yellowish, white and reddish. The mountains stand on a mesa of basalt. The first range is a little lower than the third(Tap.?) all basaltic with precipitous masses on the sides or loose blocks, below the lower mesa, There are broad fields on the summits of the Pliocene and trees and grass like parks

Page 24

8-14-1874

Examined Pliocene badlands NE of San Ildefonso

found Mastodon, rhinoceros, ?tapir mandible, camel, Merychyus, Testudo, Cathartes.

Notes from E. D. Cope's Original Notebook of 1874 Expedition.

Page 24

"

8-18-1874 Returned; crossing badlands near Pojauque found skull of Rhinoceros with good teeth of the type of Aphelops. "

Page 25
8-19- 1874

(Shows sketch of mastodon mandible with complete measurements and several notations which were not copied. T.G.) Notation says that mandible was found by W. G. Shedd.

No. 2"Maxillary bone about 200 yds. off with 3 or 4 teeth"(Gives description. T.

Page 30 (8-19 continued)
"
5 camel teeth, very small with 2 mandible teeth, long teeth, straight caniniform

Page 30

8-20-1874 "Maxillary teeth large camel mandible. Horse with other bones very rotten ...one toe..hence probably Pliohippus"

Page 31

"Mastodon No. 3 fragments of premaxillary bone and tusks

Mastodon No. 4 A single molar brittle(?sp.?) parts of large turels(?sp.?) together. Lunar and cuneiform bones separate (Mastodon, antelope or camel
"
with horns x) (Meaning not clear T.G)

" Minute carnivore, incisor rodent

Horse No. 2 (Shedd)

Hipparion (upper molar)

Canis ?saevus

Camel, lower jaw

x small ruminants

2 sp. have m teeth 3-3

3 premolars sectorial with plicae 1 worn(?sp.?) 4 crescents- long diastema.

Notes from E. D. Cope's Original Notebook of 1874 Expedition

Page 32

8-21-1874

" Mr. Shedd added mandible canis and horn beams of Cervus; two teeth and tusks of several mastodons. Pt. of marginal bones of tortoise."

Page 32

8-22-1874

" Added a cervus, a Geomys and a large camel. Found a fine Merychippus, andskull, vertebrae and foreleg of Procamelus angustidens (total of species and a dog. "

Page 33

- Carnivora
  - Canis saevus
    - ursimus (underlined in ink apparently later T.G)
    - vafe
  - Martes nambianus
- Ungulata
  - Mastodon productus
  - Aphelops jemezanus (underlined in ink. T.G)
    - meridianus
  - Hippotherium ,?speciosus
  - Hippotherium calamarius (calamarius written in ink as is Protohippus)
  - Protohippus
  - Merychippus medius
  - Procamelus occidentalis
    - gracilis

Notes from E. D. Cope's Original Notebook of 1874 Expedition

P.33 continued

Pliauchenia vulcanorum

pojauquensis (both species underlined in ink)

(In Ink T.G)→Cosoryx necatus

ramosus

gemmifer

Rodent (or Castor)('or Castor was written in ink over the ent of rodent T. G.)

Panolax sanctifedaei

Hesperomus loxodon

Steneofiber pareus (?sp.?)

Aves C

Cathartes umbrosus

Reptilia

Stylemys

No. 2 Total 25 sp.

P. 34

Pliauchenia $\frac{6}{3}\ \frac{1}{1}\ \frac{1\text{-}3}{1\text{-}2}\ \frac{3}{3}$

Diastema between pml and pm2 very short. In Pl vulcanorum the diastema between c and pm, very small and foramen mentale in front of it.

P. vulcanorum equal Pro. occidentalis

P. pojauquensis equal Pro. robustus

Notes from E. D. Cope's Original Notbook of 1874 Expedition

8-24-1874

" Found two separate molar series of Hippotherium. sep. Cos. furcatus 4-5 Cos. ramosus, and 2 Cos. sheddi, and one A. teres--2-3 camel jaws and two castor. Shedd a Hesperomys, one frag. of lower jaw horse alone. Plastron of Stylemys."

(Between Aug.24 and Aug. 30 Cope visited Algodones, Placita and Sandia Mts. during which he found Elephas primigenius remains in a 40 foot bed of marl which he called the Placitas marl T.G.)

8-30-1874 Rode out to camp via Nambe and Bad Lands found one bad camel jaw.

8-31-1874 Rode up to Abiquiu met Klett's party.

APPENDIX 3

PROPOSAL FOR CONTINUATION OF SURVEY OF PALEONTOLOGICAL RESOURCES IN THE BUREAU OF LAND MANAGEMENT RIO GRANDE RESOURCE AREA, SOUTHERN PART, BY THE UNIVERSITY OF NEW MEXICO

Background

Parts of the Rio Grande Resource Area, Southern Part (S.R.G.R.A.) have yielded one of the largest and most intensively collected Tertiary vertebrate faunas in the world. These collections include many thousands of individual bones and nearly 200 partial and complete skeletons from the Santa Fe Group. Almost all of these collections were made over a 40 year period (1924-1965) by parties sponsored by the American Museum of Natural History (A.M.N.H.). The present U.N.M. survey of the paleontological resources of the S.R.G.R.A. summarizes localities and collections from this area, but time was not available to do a detailed study of the nature and extent of collections from each locality and stratigraphic unit, or to analyze early records relating to specific important sites. The trmendous quantity and importance of the fossil materials collected by the A.M.N.H. from the S.R.G.R.A. and adjacent areas, and the imprecision of much of the earlier data regarding collections and specific localities, make it imperative that the U.N.M. survey be extended by additional analyses and compilation of information, to produce an exceptionally complete and detailed study of these resources. The problems involved in synthesizing available information and the need for an extension of the present study is documented below.

Much pertinent information on sites collected in earlier (pre-1942) phases of A.M.N.H. activity, as well as all of the material collected, is at the A.M.N.H., in New York. This data, however, is not in a form that will allow direct and efficient retrieval. Information on early localities is buried in field notebooks, reports and letters that would require a person intimately familiar with the procedures and yearly collecting activities of A.M.N.H. personnel in New Mexico to interpret. Prior to 1942, accurate locality and stratigraphic information was rather uncommonly reported. Partly this was due to the secrecy of Childs Frick, who supported and direc the A.M.N.H. collecting activities in the Santa Fe Group. Large collections containing many new types of vertebrate fossils were mad within what is now the S.R.G.R.A., but locality information is vague and usually limited to very general references, such as "around Santa Cruz", or "First Wash area". Data on exact locality and stratigraphic horizon within these general areas was often not even includ with the specimens collected. Such information is essential to have however, if the future paleontologic potential of specific sites is to be assessed, and if the land containing these fossil materials is to be properly managed.

The vagueness of early locality and collection information is unfortunate also because the type (standard reference) sections for two of the most fossiliferous Santa Fe members, the Skull Ridge and Nambe members, are present within the S.R.G.R.A. These sections provide a well-defined stratigraphic framework for many of the Santa Fe exposures, yet most of the fossils collected over the years canno be adequately fitted into this framework. Thus, detailed statements cannot at present be made regarding the stratigraphic position of ma important fossil collections, although this data is essential in predicting the future yield of paleontological materials from specif beds exposed within the S.R.G.R.A.

In addition, only about 1/4 to 1/3 of the A.M.N.H. specimens from central New Mexico have been catalogued; some have not even been removed from their shipping boxes. A complete census of the Santa Fe fossils, in order to tie them to specific, rather than general, localities, has not been attempted even by A.M.N.H. personnel, yet is a necessary element in a complete survey of fossil distribution within the S.R.G.R.A. One of many examples of this situation are the fossils removed from White Operation Quarry. This quarry was one of the largest excavations of fossil vertebrates in the S.R.G.R.A., yet complete data on what bones and skeletons were removed, and the diversity and abundance of the different types of animals, is unavailable at present. Even the exact location of this quarry is known to us only because we were escorted there by Mr. Ted Galusha, who spent many years supervising A.M.N.H. collecting activities in north central New Mexico.

Much of the information needed to completely survey the paleontological resources of the Santa Fe Group within the S.R.G.R.A. is in a form that could be extracted and interpreted only by a person with: 1) extensive and long-standing experience participating in A.M.N.H. collecting operations in central New Mexico, particularly during the earlier (pre-1942) phases for which records are inadequate, 2) first hand knowledge of long-deceased A.M.N.H. collectors who wrote reports and letters about collections and sites in the 1920's and 1930's, and 3) intimate knowledge of the sources of unpublished information relating to the A.M.N.H.'s collecting in north and central New Mexico. Such a person would also be able to supply much information from his unrecorded experiences and from memory of conversations with members of early field parties.

Proposal

The U.N.M. team has summarized the paleontological collections and localities as completely as possible using available information. As noted above, much information of importance to land management decisions is apparently unavailable, inaccessible or in a form that could not be interpreted in detail under the time and funding consttaints of the present contract. We propose here a continuation of this contract, in order to locate, review, analyze and interpret existing unpublished information on early collecting operations, localities and specimens from the Santa Fe Group, north central New Mexico, and to relate specific specimens and skeletons in the A.M.N. collections to early fossil sites and strata.

The most critical part of this study would be the addition, on continuous basis, of a scientist with the experience mentioned above. The only person still living who was involved in collecting and prospecting efforts in the earlier phases of A.M.N.H. activity on the Santa Fe Group is Mr. Ted Galusha. Mr. Galusha participated in fieldwork in and around the S.R.G.R.A. from the 1930's and supervised fossil collecting operations from 1942 until 1965. He would be uniquely able, because of his familiarity with the area and with the collecting activities of long deceased A.M.N.H. and Frick paleontologists, to interpret old records and provide much additional information on many aspects of the paleontological resources of the Santa Fe-Espanola area. Time is critical; Mr. Galusha is 67 years old. When he dies much information of great importance to the proper managing of Santa Fe Group paleontological resources will be irretrievably lost.

Under a continuation of the present contract, the following would be accomplished:

1) Examination of all pertinent notes, letters, reports, etc. at the A.M.N.H. and elswhere for precise locality information for fossil collected in the Santa Fe Group, particularly prior to 1942. Some of this information would come from Mr. Galusha's unrecorded experiences and from memory of conversations with now-deceased workers of the 1920's to 1940's.
2) Provide a set of topographic maps and aerial photographs with all localities in and around the Santa Fe Group in the S.R.G.R.A. precisely indicated. This would extend the present U.N.M. study by pinpointing many sites now designated only to nearest section or general area. In addition, B.L.M. site forms would be completed for each specific fossil locality.
3) Summarize from unpublished records and examination of the A.M.N.H collections the amount and type of fossils recovered from all sites, particularly earlier ones. This would include a detailed record of field and catalogue numbers, identification of skeletal parts represented by each fossil, and general taxonomic identification of the remains. The result would be a complete inventory of the A.M.N.H. fossil collections from the Santa Fe Group.
4) Summarize in detail the stratigraphic position of each significan deposit of fossils, at least to the extent possible by existing records. This summary would include data on fossils removed from each stratigraphic bed during the time covering the entire span of A.M.N.H. operations, and would facilitate prediction of the bed and areas likely to provide additional important material.
5) Summarize each year's collecting activity, indicating people involved, areas prospected and collected, and a sequential yearly

record of fossil materials removed, tied to catalogue and specimen numbers in the A.M.N.H. collections. This primarily historical information would also include a complete list of unpublished documents available relating to paleontological resources of the Santa Fe Group.

6) Field check important localities, especially quarries worked before and after 1942, and related stratigraphic and site locatio information to determine their accuracy. This would involve measuring additional stratigraphic sections and similar field activities to adequately tie old sites into the presently accepted stratigraphic framework.

Assembling the information that would come from the studies outlined above would not only provide a detailed basis for land management decisions relative to the paleontological resources in this area, but would also be a work of great importance to the discipline of paleontology and would encourage additional specialized work on the Santa Fe Group fossils, resulting in a continuous flow of information that would be of use to land management agencies.

This proposed continuation of the present U.N.M. study would involve more time and expense than the original study, but in our view is a necessary supplement for the following reasons: 1) The Santa Fe has been more completely and continuously sampled for vertebrate fossils than any other Tertiary deposit in North America, 2) Most of the tremendous number of fossils collected have not yet been catalogued, studied, or tied to specific localities and stratigraphic units, and 3) Much essential information on the collections is in a form that can only be interpreted by a scientist intimately familiar with the A.M.N.H.'s collecting activities over the period 1924-1965, and the unpublished records that relate to these activities. We have discussed the additional work needed with Mr. Galusha, and he has indicated a willingness to undertake a major role in the assemblin of the needed data. This study could only be done with his participation.

We estimate that 9 months would be required to complete the study A tentative budget is presented below.

Budget

We estimate that about 4 months would be needed in New York to study the A.M.N.H. records and collections, and another 4 months in the Espanola, New Mexico area, in order to field-check the records and integrate them into the local stratigraphic framework, and to assemble the information on topographic maps and aerial photographs. An additional month would be required to finish writing and typing the report. Mr Galusha would work full time during 8 months, and would employ museum and field assistants to help as needed. Dr. Kues would administer the project and assist in the fieldwork and in the writing of the final report. This budget can be refined if desired by the B.L.M. or U.N.M.

I. Work in New York (A.M.N.H.)	
Salary, 4 months (Galusha) @ 1800/month	$ 7,200
Living expenses (Galusha), 4 months	4,000
Xeroxing and other services	2,000
II. Work in New Mexico	
Salary, 4 months (Galusha), @ 1800/month	7,200
Living expenses, 4 months (Galusha)	4,000
Transportation, maintenance of field vehicles, field supplies, etc., 4 months	1,000
III. Additional expenses, 9 month period	
Salary, (Kues), 160 hrs @ $9.50/hr.	1,520
Salary for field assistants, personnel to help in examining and documenting collections, recording, information, etc., 9 months	7,200
Xeroxing	500
Typing, drafting, maps, etc.	5,000
SUBTOTAL	39,620
IV. Overhead, U.N.M. (=53% of salaries)	12,254
TOTAL	$ 51,874

APPENDIX 4

Localities from which fossil material was observed and/or collected during the field work.

APPENDIX 5

NEW MEXICO
STATE HIGHWAY DEPARTMENT

COMMISSION

JIM DENISON
CHAIRMAN, HOBBS
PAUL RADER
VICE CHAIRMAN, MESILLA
JAMES W. CHANEY
SECRETARY, MORIARTY
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ALBERT N. SANCHEZ
MEMBER, SANTA ROSA

1912

FRED L. O'CHESKEY
CHIEF HIGHWAY ADMINISTRATOR

P. O. Box 1149
Santa Fe, New Mexico
87503

M - TECH. SERV.

October 31, 1978

Mr. Barry S. Kues
The University of New Mexico
Department of Geology
Albuquerque, New Mexico 87131

Dear Mr. Kues:

Attached is a map indicating the information concerning Interstate 25 that you requested recently. You will note that both Alternates #6 and #7 cross the area you marked in yellow.

We have completed an Environmental Assessment for the various alternates being considered for I-25 between Bernalillo and Waldo. Public meetings will be held in the very near future. Because of your interest in this matter, I am requesting our Public Liaison Officer to add your name to the list of people to receive public meeting notices.

Should you require any additional information, please do not hesitate to contact us.

Very truly yours,

K. E. Bower, Jr., P.E.
Director - Technical Support
Division

KEB:mmb
Attachment(s)

cc: Engineer of Technical Services
Public Liaison Officer

Bureau of Land Management
Library
Denver Service Center

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

Bureau of Land Management
Library
Bldg. 50, Denver Federal Center
Denver, CO 80225

s Card

rvey, resource assessment,
n plan for the Southern half
ande Resource Area,
New Mexico.

r	Division	Date Ret'd

DSC 1279-3a (Feb. 1977)